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Coating Operations Test Method and Method Development Survey

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
AIR RESOURCES BOARD
Research Division

COATING OPERATIONS TEST METHOD AND METHOD DEVELOPMENT SURVEY

Final Report
Contract No. 93-344

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I

Project Overview

The goal of this project was to develop a plan to obtain information to guide and prioritize the development and improvement of test methods related to volatile organic compound emissions from coating applications and related operations. The tasks undertaken to meet the project goal involved: (i) the development of a plan for obtaining the current regulations and test methods from all relevant agencies; (ii) a methodology for for identifying and ranking test method problems; (iii) a list of test method problems ranked in order of priority; (iv) a procedure for updating the test method problems, and (v) a procedure for identifying projects to resolve test method problems.

Task 1 of this project involved documenting the existing regulatory requirements for coating operations and the attendant test methods currently in place to carry out those requirements. The documentation was obtained through library and computer database searches, and by direct mailing to all federal, state, and local agencies responsible for issuing regulations. The information was organized according to type of coating and coating operation. Twenty three categories were identified. All regulations applicable to each category were listed, along with the required test methods. Copies of all of the test methods were obtained from the agencies responsible for issuing them (i.e. ASTM, EPA, CARB, SCAQMD, BAAQMD, etc.). A database was developed to aid in the analysis of data. Details are given in Section II

Task 2 was to develop a methodology for analysing the documentation regarding regulations and test methods and identify any problems which exist in the test methods, particularly any problems which may require the development of improved test methods. At the time of our original direct

mailings to federal, state, and local regulatory agencies, testing organizations, etc. we surveyed them to identify problems they were aware of with the current testing methods, and to propose any ideas they had for resolving those problems. We also asked them to identify organizations (public or private laboratories, universities, etc.) who have performed each test method for them in recent years. We then contacted these organizations and asked them which tests they have performed, any problems they have encountered with the tests, and any ideas they have to improve the test methods. A list of potential problems was drawn up using the expertise of the principal investigators and the information from outside scientists who are actively involved in developing tests and performing them in actual enforcement and quality control situations. A great deal of importance was given to the real world experience of the scientists who are using these tests, so that problems which were not apparent from simply reading the regulations and test methods could be identified. Details are given in Sections III and IV.

After the list of potential problems was drawn up, the principal investigators and ARB representatives met (by telephone conference) with a committee of district representatives selected by the ARB in order to refine the list of the test method problems in order of importance and urgency (Task 3). The ideas of the members of the committee of district representatives have been incorporated into the final report. Such factors as the total amount of emissions covered by the regulations and test methods, and the cost of the test methods were important considerations in developing the list of test method problems. Details are given in Section IV.

The results and experience gained in Tasks 1-3 were then used to develop a plan that could be used in the future by ARB for updating the test method problems identified in this report (Task 4). The plan incorporates

many of the elements discussed in Tasks 1-3 above. Where necessary, we have suggested modifications based on our experience in gathering and organizing the the data. A formula is also developed so that the ranking of test methods can be made semi- quantitative. Details of the plan for updating test methods are given in Section VI, and the application of the ranking formula to the list of problems identified in Section V is given in Section VII.

Section VIII describes the proposed procedure for identifying projects to resolve test method problems (Task V).

This final report has been prepared describing the information gathered and the recommendations developed during the course of this project. All of the information gathered has been organized as described above in an appendix to the final report.

II

Survey of Existing Regulations

1. Survey Development

The initial work undertaken for this project(Task 1) involved the development and implementation of a plan for documenting the existing regulatory requirements for coatings and coating operations, and the test methods which are currently in place to carry out those requirements.

The purpose of Task 1 was to establish a methodology to document the existing regulatory requirement for VOC (volatile organic compounds) emissions from coatings and coating operations and the test methods which are currently proposed to carry out those requirements. The documentation specifically addresses emissions from coatings and coating operations. The incorporated data have been obtained through extensive surveys and person to person contact reports. It has been a goal of the initial phase of this study to utilize the data obtained from these surveys to increase our understanding of statewide VOC emissions and emissions regulations related to coatings and coating operations.

The first step in this process was a comprehensive survey of all regulations relating to coatings and coating operations which are currently on the books or under consideration by the air pollution control districts (APCDs) and air quality management districts(AQMDs) of the state of California. We began by obtaining copies of the complete Rules and Regulations for the two largest AQMDs, South Coast and Bay Area, as well as for two local districts, Sacramento and Yolo-Solano. For the other 30 APCDs and AQMDs in California we used copies of the district Rules and Regulations on file at the Air Resources Board. Complete copies were made of all district rules and regulations relating to coatings and coating operations.

From this initial survey we identified more than 100 rules and regulations distributed among 16 districts. In order to organize the rules we assigned each rule to one of 23 categories (Table 1). The categories correspond to the way in which the district rules and regulations are written (i.e. each category generally represents one rule, although a few categories include more than one rule).

Table 1: CLASSIFICATION OF COATING CATEGORIES

Category No.	Type of Coating
1	Architectural
2	Metal Parts and Products
3	Motor Vehicle and Mobile Equipment
4	Graphic Arts
5	Can and Coil
6	Aerospace Parts and Products
7	Wood Products
8	Polyester Resin Operations
9	Paper, Film, and Fabric
10	Marine Vessel
11	Adhesives and Sealants
12	Ink and Adhesive Manufacturing
13	Solvent Cleaning Operations
14	Metal Coating Thinner and Reducer
15	Semiconductor Manufacturing Operations
16	Aerosol
17	Resin Manufacturing
18	Plastics, Rubber, and Glass
19	Magnetic Wire
20	Organic Solvents
21	Appliance and Metal Furniture
22	Wood Furniture Manufacturing
23	Miscellaneous

2. Follow-up Survey

After we had compiled the initial list of rules and regulations for all of the APCDs and AQMDs in California, we prepared a survey letter to send to

all of the districts in the state. The letter, Survey A1 (Appendix A), consisted of a cover letter which described the project and its goals, and requested the cooperation and assistance of district personnel. Accompanying the letter was a questionnaire which listed all district rules and regulations regarding coatings and coating operations that had previously been identified. The focus of this questionnaire was to list any new or proposed rules of which we were not aware. The contacts that were made with district personnel for this survey are listed in Table A1.

3. Data Collection and Survey Response

The compilation of data resulting from responses to written and verbal surveys of federal, state and local government agencies, as well as private organizations, has been facilitated by the use of FileMaker Pro 2.2. FileMaker Pro 2.2 is a database software program capable of handling large amounts of data, enabling the user to create documents, sort data according to specific search terms, and retrieve single as well as multiple files relating to particular subjects. In organizing the data, this study has created a basic layout of the gathered information, which was later manipulated to produce reports specific to certain categories and districts. Table A2 shows a representative sample of such a basic layout. In this layout, vital information concerning the category number in question is listed along with the testing methods cited by the district for regulation of the coating operation. The rule numbers listed in Table A2 illustrate those testing methods currently being utilized by the districts in question. Status refers to the current status of the regulations, where existing regulations are currently in force, and proposed regulations are still under consideration by the district. As a result of our library search of district regulations, and our survey of the individual districts, it was obvious to us that there were three classes of districts in the state with regard to rules

regulating coatings and coating operations. First, there were the districts representing the major urban areas, with 6 or more regulations each, then there were the intermediate districts covering the smaller urban areas of the state, which have a few regulations covering particular local industries, and which may be adding new regulations as their areas grow, and finally there were the districts representing the rural areas of California, which currently have no regulations covering coatings or coating operations (Figure 1).

- Two districts combined account for 38% of all the regulations of coating operations within the state (South Coast and Bay Area)

- Six districts combined account for nearly 47% of the remaining regulations of coating operations within the state (Sacramento, San Diego, San Joaquin Valley Unified, Santa Barbara, Yolo-Solano, and Ventura)

- Architectural coatings(12%), Metal Parts and Products(9%) and Motor Vehicle and Mobile Equipment(9%) represent the most frequently regulated sources of VOC emissions within the state of California (from coatings and coating operations).

We received responses to our survey of district rules from most of the districts (23 of 34, 68%), including all of the districts which we had identified as having existing rules and regulations concerning coatings and coating operations. After completion of the survey we identified 16 districts which had a total of 116 rules currently in place to deal with VOC emissions from coatings and coating operations. It can be seen from Table 2 that the South Coast and Bay Area AQMDs currently account for 38% of all rules dealing with coatings and coating operations, and that six additional districts account for nearly all the remaining rules. This is not really a surprising result, since these eight districts represent nearly all of the major urban areas in the state.

We were also able to use the responses to our survey to update our list of contact persons at the districts.

4. Results and Data Analysis of Survey Effort

Information regarding regulations and test methods relating to coating operations has been organized according to each type of coating and coating operation. Those processes associated with the manufacture and use of coating, printing, and adhesive materials, and solvent cleaning agents, or equipment related to those activities and materials have been further subdivided according to relevant characteristics. Table 1 identifies these characteristics and associates a category number for each grouping of related characteristics.

Table 1 represents a classification scheme for the coating operations existing within the state of California. This classification of coating categories identifies a unique category number with a particular grouping of coating types. The identification scheme is divided into 23 separate coating category numbers. These category numbers define particular sources of VOC emissions from generic coatings and coating operations. The order in which the coating categories are listed in Table 1 is arbitrary and the category numbers function only to provide a systematic means of labeling the coating categories. In examining this classification scheme, it must be noted that this study has utilized category 23 to represent the various coatings and coating operations that are not represented in categories 1-22. These miscellaneous coatings and coating operations include, but are not limited to consumer products, surfactant manufacturing and organic materials emissions.

The establishment of coating category numbers further enables the study to identify the districts within the state of California that are currently regulating VOC emissions. Table 2 identifies the number of categories

associated with a particular district as well as the number of regulations pertaining to coating operations that exist within the district. The number of regulations does not always match the number of categories. In certain instances the number of regulations exceeds the number of categories—this is a result of the manner in which this study has defined the types of coatings/coating operations. Districts not listed in Table 2 have no existing regulations in the categories outlined in Table 1.

Table 2: DISTRICTS WITH EXISTING REGULATIONS

District	Categories	Rules
Bay Area	21	22
Butte	1	1
El Dorado	3	3
Imperial	2	2
Kern	4	4
Monterey Bay Unified	2	2
North Coast Unified	1	1
Placer	2	2
Sacramento	6	6
San Diego	10	10
San Joaquin Valley Unified	11	11
San Luis Obispo	3	3
Santa Barbara	8	8
South Coast	19	23
Yolo-Solano	8	8
Ventura	11	11
Total No. of Districts	16	
Sum of Rules Statewide	117	

Table 3 summarizes how different coatings and coating operations are regulated in each district. It identifies all the districts within the state of

Table 3: STATEWIDE ACCOUNTING FOR CATEGORIES

	Categories																						
District	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*	*Total*
Amador																								0
Bay Area	1	1	2	1	1	1	1	1	1	1	1	1			1	1	1	1	1	1	1	1	1	22
Butte	1																							1
Calaveras																								0
Colusa																								0
ElDorado	1		1	1																				3
FeatherRiver																								0
Glenn																								0
GreatBasinUnified																								0
Imperial	1					1																		2
Kern	1	1	1	1																				4
Lake																								0
Lassen																								0
Mariposa																								0
Mendocino																								0
Modoc																								0
MojaveDesert																								0
MontereyBayUnified	1	1																						2
NorthCoastUnified																							1	1
NorthernSierra																								0
NorthernSonoma																								0
Placer	1				1																			2
Sacramento	1	1			1	1							1										1	6
SanDiego	1	1		1	1	1	1	1	1	1		1												10
SanJoaquinValley Unified	1	1	1	1	1	1	1	1			1	1								1				11
SanLuisObispo		1	1																				1	3
SantaBarbara	1	1	1	1		1	1	1						1										6
Shasta																								0
Siskiyou																								0
SouthCoast	1	1	2	1	1	1	1	1	1	2	1	1	1		1	1	1	1	1			1	2	23
Tehama																								0
Tuolumne																								0
Ventura	1	1	1	1		1	1	1	1		1		1		1									11
Yolo-Solano	1	1	1	1				1			1		1							1				6
Subtotal	14	11	11	9	8	8	6	7	4	4	5	4	4	1	3	2	2	2	2	3	1	2	6	111

* Categories with a value greater than one identify those districts having multiple regulations for that specific category

Summary:
Total number of documented records
116
Number of districts containing zero categories
18
Number of records with districts containing repeated categories
4
Number of single incidence records
112

California involved in regulating coating operations, as well as which categories are currently regulated by each of the districts. This summary also lists the categories existing within each district, identifying those districts having multiple regulations set aside for specific coating operations.

Figure 1 is an intensity index of district involvement in coating regulations within the state of California. Figure 1 identifies those districts most heavily represented in regulating coating operations by assigning a color scheme to identify the number of district regulations related to coating operations. A geographical index of how coating categories are distributed throughout the state of California is provided in Appendix A (Figures A1-A4).

The geographical index cites the particular district as being responsible for regulating the said coatings and coating operations (by category number). The Sacramento APCD, for example, cites the following coating categories (1, 2, 5, 6, and 13) (see Table 3) as the ones currently being regulated within the district. However, certain categories for which industries exist have not been cited. The most obvious of these omissions are the microcomputer companies, which include Apple, NEC, Hewlett Packard, and Packard Bell. Since the computer industry is involved in processes relating to semiconductor manufacturing, it is surprising that category 15 (which involves semiconductor manufacturing operations) is not included on the list. Its omission indicates a potential discrepancy in the manner in which districts regulate coating operations.

Table 2, in conjunction with Figure 1 identifies two districts with more than 12 coating categories cited within their districts. These figures are significant because they clearly identify the two districts most heavily involved in coating operations—Bay Area and South Coast AQMD. In

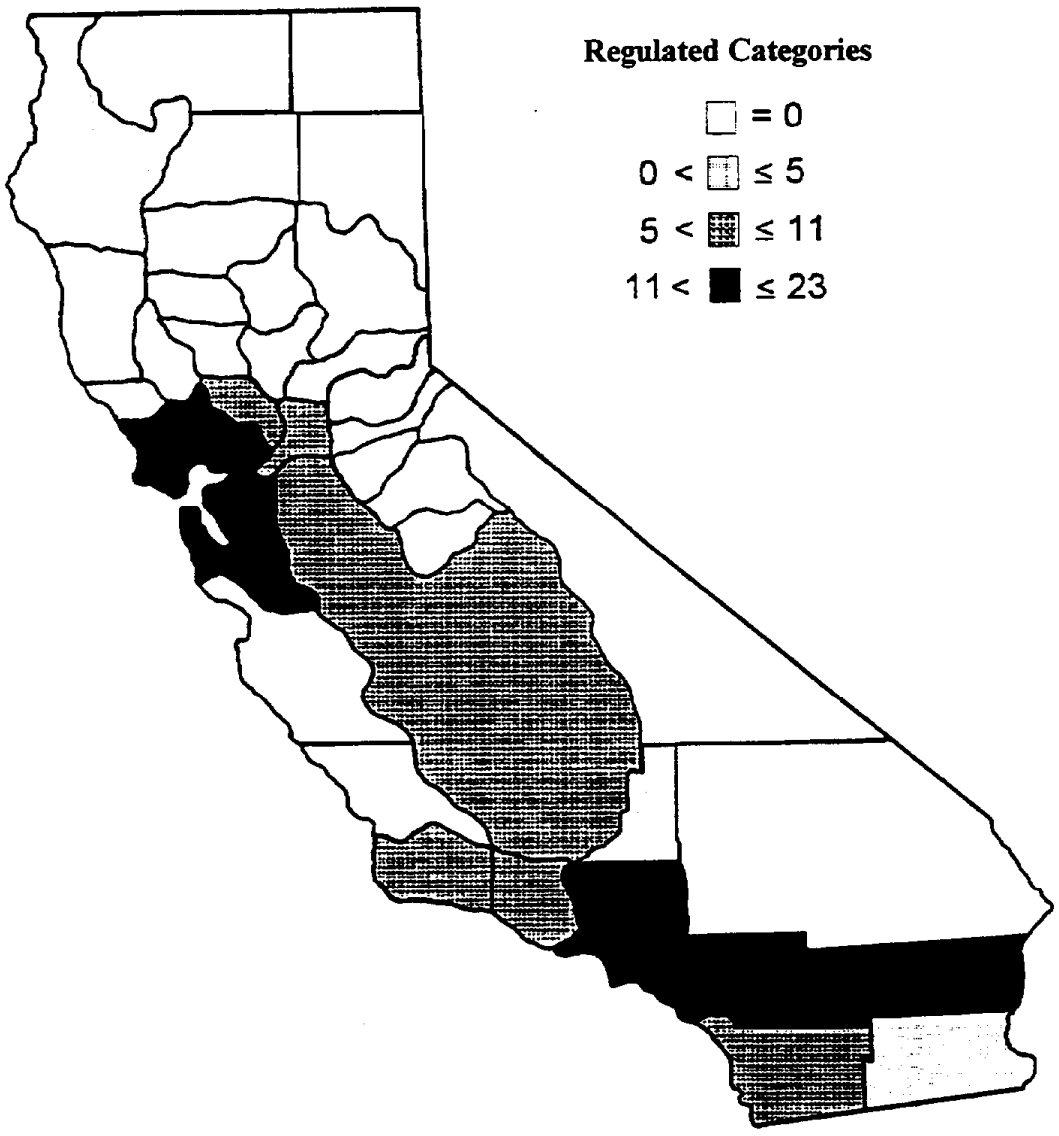


Figure 1: Geographic Intensity Index of District Involvement in Coating Categories

establishing future programs involving VOC emissions, districts such as the Bay Area and South Coast are particularly important because these districts contain a representative sample of all the coating categories existing within other districts. Figure 2 summarizes the degree to which districts within the state of California are involved in coating regulations. The particular coating categories regulated by the districts represent the degree of involvement. Taking Kern county as an example, the coating categories that are regulated include 1, 2, 3, and 4. In comparison, South Coast AQMD is a region with many more types of regulated coating categories (e.g. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, and 23). The involvement of districts in regulating coating operations identifies regions of probable VOC emissions, with those districts maintaining a higher degree of involvement being potentially responsible for larger amounts of VOC emissions.

Figure 3 summarizes the extent to which individual coating categories, as seen in Table 1, are regulated by the state of California. The significance of cataloguing the relative incidence of coating categories is to identify those coating categories which represent a significant percentage of coating operations on a statewide basis. For example, architectural coatings are cited a total of 15 times by the districts as being a potential source of VOC requiring regulation within their districts. In comparison, resin manufacturing is cited only two times by the districts as being a source of VOC emissions. One could argue that the increased incidence of architectural coating regulations over resin manufacturing regulations indicates that architectural coatings are more prevalent than resin manufacturing within the state of California as sources of VOC's. The degree to which individual coating categories affect the state of California is important, for it allows for the identification of those

Figure 2: DISTRICT INVOLVEMENT IN COATING CATEGORIES

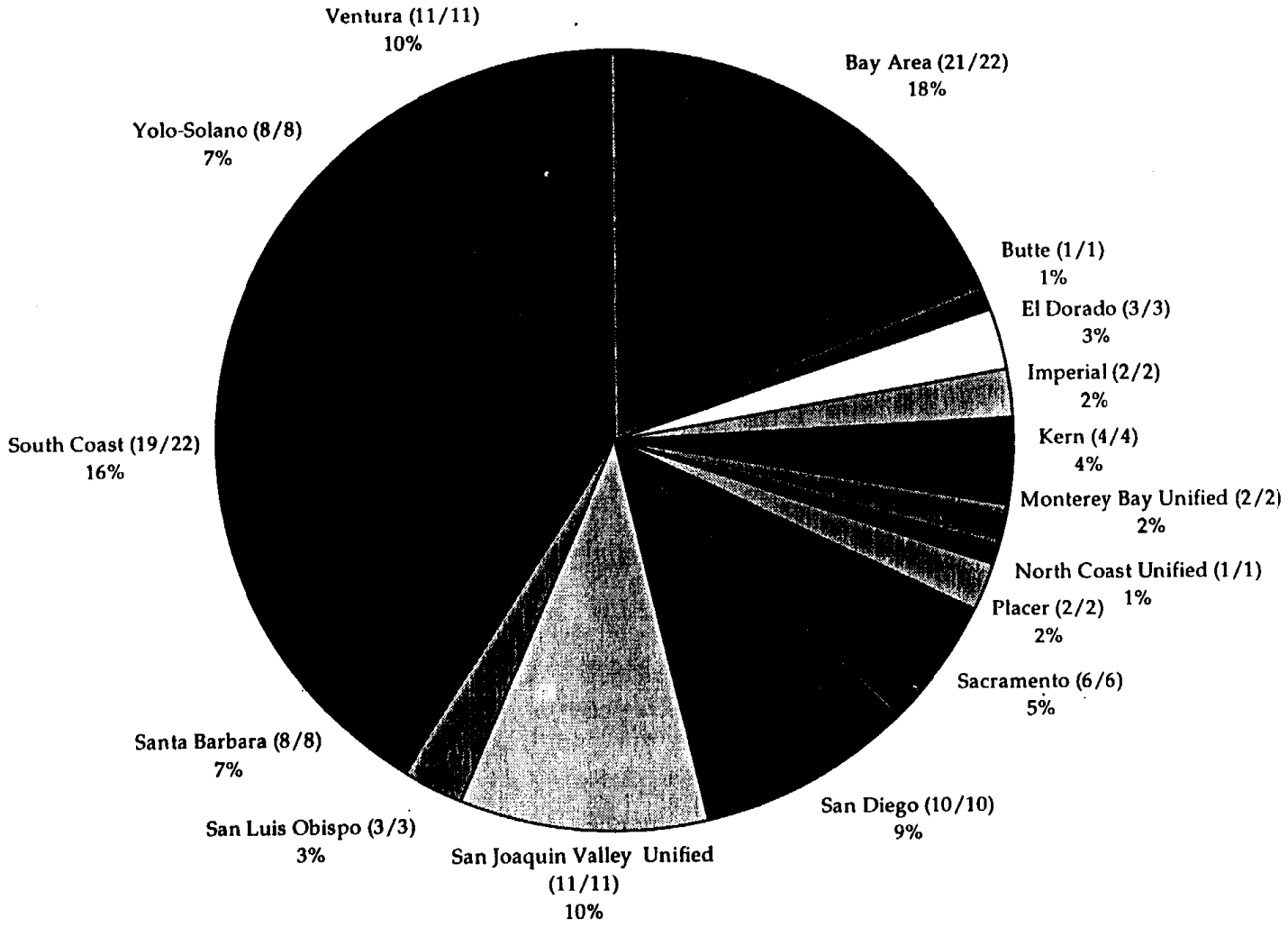
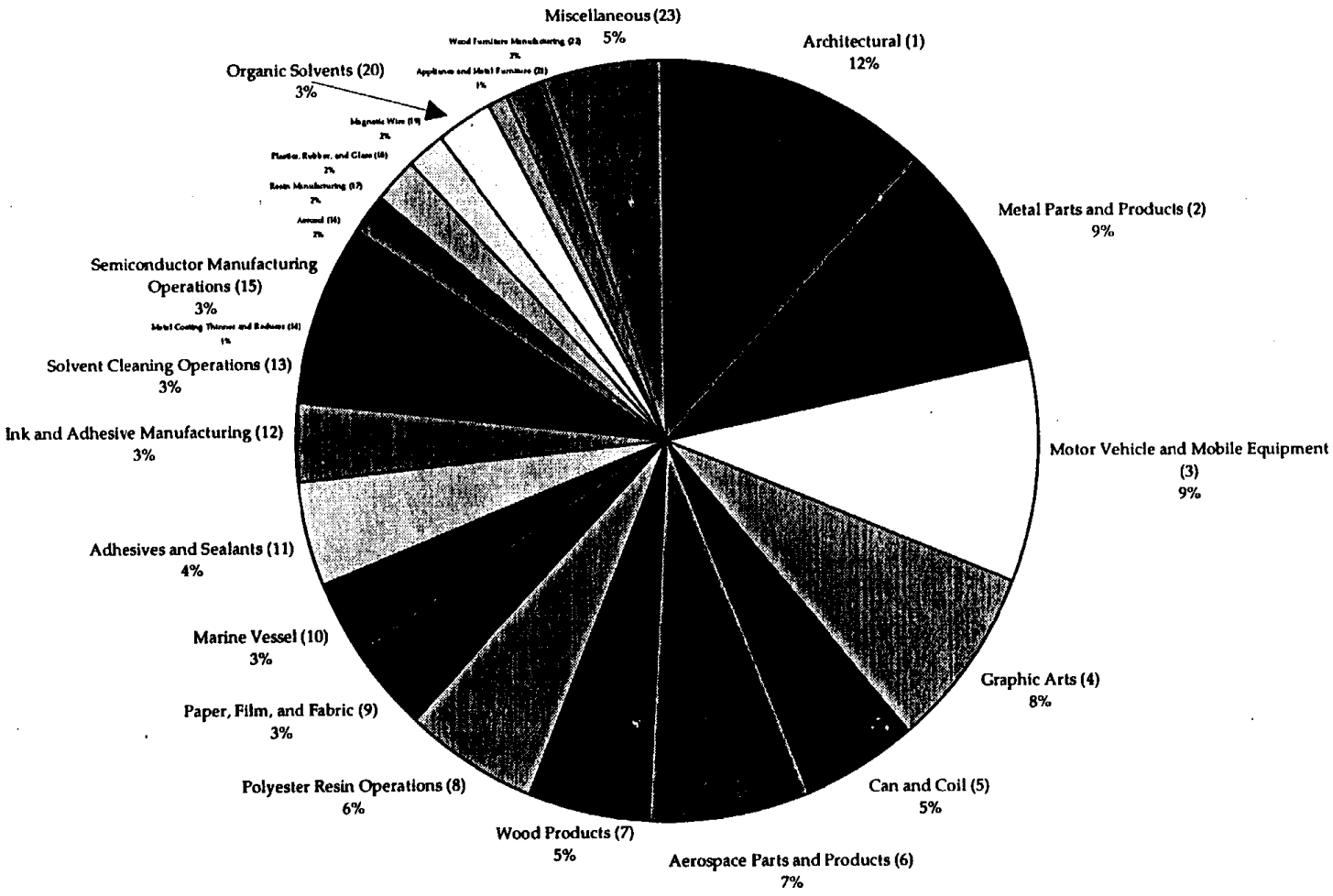


Figure 3: RELATIVE FREQUENCY OF CATEGORIES STATEWIDE



coating categories comprising the majority of VOC emissions from coating operations. Figure 3 in no way accounts for the VOC emissions from particular coating categories, but merely seeks to identify those categories which are potentially significant as sources of VOC emissions.
For the purposes of this study, we made the decision to focus our efforts primarily on the eight major urban districts (South Coast, Bay Area, San Joaquin Valley, Ventura, San Diego, Santa Barbara, Yolo-Solano, and Sacramento). These districts represent virtually all of the existing rules dealing with coatings and coating operations in the state of California, and therefore they must also be the areas for which most of the test methods for VOC emissions from coatings and coating operations are required.

In the course of obtaining our complete list of all district rules and regulations concerning coatings and coating operations, we compiled an inventory of all test methods relating to VOC emissions which are cited in the various district rules. They are listed in Table 4 according to the specific rule in which they are cited (i.e. each district rule concerning coatings and coating operations is listed along with all test methods relating to VOC emissions cited in that rule). Organizing the test methods in this manner was done in order to ensure that we had a complete list of all test methods cited in all of the district rules.

In order to study the test methods and begin to formulate a list of problems with the current test methods, it was more useful to organize them according to the government or private agency responsible for developing or certifying the method (Table 5). In Table 5 we have grouped the test methods relating to VOC emissions from coatings and coating operations according to the federal, state, or private agency responsible for that method: the United States Environmental Protection Agency (EPA), the California Air Resources

Board (ARB), the American Society for Testing and Materials (ASTM), and the South Coast and Bay Area Air Quality Management Districts SCAQMD, BAAQMD).

Table 5: ITEMIZED VOC TESTING METHODS

EPA Methods:	18, 24, 24A, 25, 25A, 25B, 25D, 40 CFR 52.741, 40 CFR 60.713, 55 FR 26865
ARB Methods:	100, 422, 432
ASTM Methods:	D-1613-81 (or -85), D-1639-83, D-3792-79 (or -86), D-1078-86, D-2879-83 (or -86), D-3960-87, 2306-81, D-2369-87, D-4457-85, E-260-85 (or -91)
SCAQMD Methods:	304, 25.1, 26, 302, 303, 304, 305, 309, 310, 311, 312, 316A
BAAQMD Methods:	III-9, III-21, III-22, III-23, III-26, III-31, III-35, III-36, IV-ST-7

Although the test methods are more manageable organized in this manner, it is still a rather formidable list, comprising 50 methods from five different agencies. However, this list is somewhat misleading, since a number of the methods actually overlap or are equivalent to one another. For example, EPA Method 24 includes a number of the ASTM methods listed in Table 5. Therefore, while the list of test methods for VOC emissions from coatings and coating operations is substantial, it can be further categorized according to three broad classes of test methods: (1) laboratory test methods, (2) source test

methods, and capture efficiency test methods, and (3) transfer efficiency test methods.

Table 4: Survey of Coating Regulations of Districts

Category No.	Rule Title (Exact)	Rule No.	District	Test Method 1	Test Method 2	Test Method 3	Test Method 4	Test Method 5	Status
None	None	None	Amador County APCD	None					N/A
1	Architectural Coatings	3	Bay Area AQMD	BAAQMD III 21, 22					Existing
5	Metal Container, closure, and coil coating operations	11	Bay Area AQMD	EPA 25, 25A	BAAQMD III 21, 22	BAAQMD IV ST-7			Existing
9	Paper, fabric, and film coating	12	Bay Area AQMD	EPA 25, 25A	BAAQMD III 21, 22	BAAQMD IV ST-7			Existing
2	Surface coating of miscellaneous metal parts and products	19	Bay Area AQMD	EPA 25, 25A	BAAQMD III 21, 22	BAAQMD IV ST-7			Existing
4	Graphic arts printing and coating operations	20	Bay Area AQMD	EPA 25, 25A, 24, 24A	BAAQMD III 21, 22	BAAQMD IV ST-7			Existing
6	Aerospace assembly and component coating operations	29	Bay Area AQMD	BAAQMD III 21, 22	BAAQMD IV ST-7				Existing
15	Semiconductor manufacturing operations	30	Bay Area AQMD	EPA 25, 25A	BAAQMD IV ST-7				Existing
7	Wood products coatings	32	Bay Area AQMD	EPA 25, 25A	BAAQMD III 21, 22, 31	BAAQMD IV ST-7			Existing
12	Coating, ink and adhesive manufacturing	35	Bay Area AQMD	EPA 25, 25A	BAAQMD III 31	BAAQMD IV ST-7			Existing
10	Surface coating of marine vessels	43	Bay Area AQMD	EPA 25, 25A	BAAQMD III 21, 22	BAAQMD IV ST-7			Existing
3	Motor vehicle and mobile equipment coating operations	45	Bay Area AQMD	EPA 25, 25A	BAAQMD III 21, 22	BAAQMD IV ST-7			Existing
8	Polyester resin operations	50	Bay Area AQMD	EPA 25, 25A	BAAQMD III 26, 31, 23	BAAQMD IV ST-7			Existing

Table 4 *Continued*: Survey of Coating Regulations of Districts

Category No.	Rule Title (Exact)	Rule No.	District	Test Method 1	Test Method 2	Test Method 3	Test Method 4	Test Method 5	Status
11	Adhesiveandsealantproducts	51	Bay Area AQMD	BAAQMDIII21, 22,35,36	BAAQMDIV ST-7				Existing
20	Generalsolventandsurfacecoating operations	4	Bay Area AQMD	EPA25,25A	BAAQMDIII9	BAAQMDIV ST-7			Existing
21	Surfacecoatingoflargeapplianceand metalsfurniture	14	Bay Area AQMD	EPA25,25A	BAAQMDIII21, 22	BAAQMDIV ST-7			Existing
22	Coatingsofflatwoodspanelingand wood flat stock	23	Bay Area AQMD	EPA25,25A	BAAQMDIII21, 22	BAAQMDIV ST-7			Existing
19	Magneticwirecoatingoperations	26	Bay Area AQMD	BAAQMDIII21, 22	BAAQMDIV ST-7				Existing
18	Surfacecoatingofplasticpartsand products	31	Bay Area AQMD	EPA25,25A	BAAQMDIII21, 22	BAAQMDIV ST-7			Existing
17	Resinmanufacturing	36	Bay Area AQMD	BAAQMDIV ST-7					Existing
23	Flexibleandrigiddiscmanufacturing	38	Bay Area AQMD	BAAQMDIII21, 22	BAAQMDIV ST-7	EPA25,25A			Existing
16	Aerosolpaintproducts	49	Bay Area AQMD	BAAQMDIII35, 36					Existing
3	Lightandmediumdutymotorvehicle assemblyplants	13	Bay Area AQMD	EPA25,25A	BAAQMDIII21, 22	BAAQMDIV ST-7			Existing
1	ArchitecturalCoatings	240	ButteCountyAPCD						Existing
3	Automobilefinishcoatings		ButteCountyAPCD						Proposed

Table 4 *Continued*: Survey of Coating Regulations of Districts

Category No.	Rule Title (Exact)	Rule No.	District	Test Method 1	Test Method 2	Test Method 3	Test Method 4	Test Method 5	Status
2	Metal parts coatings		Butte County APCD						Proposed
18	Plastic parts coatings		Butte County APCD						Proposed
21	Metal furniture coatings		Butte County APCD						Proposed
9	Paper and fabric coatings		Butte County APCD						Proposed
7	Wood furniture manufacturing		Butte County APCD						Proposed
10	Marine coatings		Butte County APCD						Proposed
22	Flat-wood panels coatings		Butte County APCD						Proposed
11	Commercial/industrial adhesives		Butte County APCD						Proposed
5	Can and coil coatings		Butte County APCD						Proposed
None	None	None	Calaveras County APCD	None					N/A
None	None	None	Colusa County APCD	None					N/A
1	Architectural Coatings	215	El Dorado County APCD	None					Existing
3	Automotive refinishing operations	230	El Dorado County APCD	None					Existing
4	Graphic arts operations	231	El Dorado County APCD	None					Existing
None	None	None	Feather River AQMD	None					N/A

Table 4 *Continued*: Survey of Coating Regulations of Districts

Category No.	Rule Title (Exact)	Rule No.	District	Test Method 1	Test Method 2	Test Method 3	Test Method 4	Test Method 5	Status
None	None	None	Glenn County APCD	None					N/A
None	None	None	Great Basin Unified APCD	None					N/A
1	Architectural Coatings	424	Imperial County APCD	EPA24					Existing
6	Aerospace Coating Operations	425	Imperial County APCD	EPA24	ASTM D-4457-85	ASTM D-3960-87			Existing
1	Architectural Coatings	410.1	Kern County APCD	EPA24	ARB 432,422	EPA 25,25A,25B	ASTM D-1613-81	SCAQMD	Existing
2	Surface coating of metal parts and products	410.4	Kern County APCD	EPA24	ARB 432,422	EPA 25,25A,25B	ASTM D-1613-85	SCAQMD 311-91	Existing
3	Motor Vehicle and Mobile equipment and refinishing operations	410.4A	Kern County APCD	EPA24	ARB 432,422	EPA 25,25A,25B	ASTM D-1613-81	SCAQMD	Existing
4	Graphic Arts	410.7	Kern County APCD	EPA24,24A	ARB 432,100	BAAQMD 30	EPA 25		Existing
None	None	None	Lake County AQMD	None					N/A
None	None	None	Lassen County APCD	None					N/A
None	None	None	Mariposa county APCD	None					N/A
None	None	None	Mendocino County APCD	None					N/A
None	None	None	Modoc County APCD	None					N/A
None	None	None	Mojave Desert AQMD	None					N/A

Table 4 *Continued*: Survey of Coating Regulations of Districts

Category No.	Rule Title (Exact)	Rule No.	District	Test Method 1	Test Method 2	Test Method 3	Test Method 4	Test Method 5	Status
1	ArchitecturalCoatings	426	Monterey Bay AQMD	EPA24	ARB432				Existing
2	Coatingofmetalspartsandproducts	434	Monterey Bay AQMD	EPA24	ASTMD-4457-85	ASTM-1613-85	SCAQMD311	ASTMD-1048-86	Existing
23	NewSourcePerformanceStandards	490	North Coast Unified AQMD	None					N/A
None	None	None	Northern Sierra AQMD	None					N/A
None	None	None	NorthernSonoma CountyAPCD	None					N/A
1	ArchitecturalCoatings	218	Placer County APCD	None					Existing
5	Cancoatings	223	Placer County APCD	EPA24	ASTMD-3792	ASTMD-4457			Existing
1	ArchitecturalCoatings	442	Sacramento MetropolitanAQMD	EPA24	ARB432	ASTMD-4457-85			Existing
23	Rotogravureandflexographicprinting	450	Sacramento MetropolitanAQMD	EPA24	ARB432	ASTMD-4457-87			Existing
2	Surfacecoatingofmiscellaneous metalpartsandproducts	451	Sacramento MetropolitanAQMD	EPA24	ARB432	ASTMD-4457-89			Existing
5	Cancoatings	452	Sacramento MetropolitanAQMD	EPA24	ARB432	ASTMD-4457-91			Existing

Table 4 *Continued*: Survey of Coating Regulations of Districts

Category No.	Rule Title (Exact)	Rule No.	District	Test Method 1	Test Method 2	Test Method 3	Test Method 4	Test Method 5	Status
13	Degreasingoperations	454	Sacramento MetropolitanAQMD	EPA24	ARB432	ASTMD-4457-93			Existing
6	Aerospaceassemblyandcomponent coatingoperations	456	Sacramento MetropolitanAQMD	EPA24	ARB432	ASTMD-4457-95			Existing
1	ArchitecturalCoatings	67	San Diego APCD	EPA24	ASTMD-4457-85	ASTMD-3792-86	ASTMD-3960-87	ASTMD-1613-81	Existing
2	Coatingofmetalspartsandproducts	67.3	San Diego APCD	EPA24,18,25	ASTMD-4457-85	ASTMD-3792-86	ASTMD-3960-87	ASTMD-1613-81	Existing
5	Metal Container, closure, and coil coatingoperations	67.4	San Diego APCD	EPA24,25	ASTMD-4457-85	ASTM-3792-86	ASTMD-3960-87	40CFR60.713	Existing
9	Paper, film, and fabric coating operations	67.5	San Diego APCD	EPA24,18,25	ASTMD-4457-85	ASTM-3792-86	ASTMD-3960-87		Existing
6	Aerospacecoatingoperations	67.9	San Diego APCD	EPA24,18,25, 25A	ASTMD-4457-86	ASTMD-3792-87	ASTMD-3960-88	ASTMD-1613-81	Existing
7	Woodproductcoatingoperations	67.11	San Diego APCD	EPA24,18,25	ASTMD-4457-85	ASTMD-3792-86	ASTMD-3960-87	ASTMD-2369-87	Existing
4	GraphicArtsOperations	67.16	San Diego APCD	EPA24,24A, 18,25,25A	ASTMD-4457-85	ASTMD-3792-86	ASTMD-3960-87	ASTMD-2879-83	Existing
8	Polyesterresinoperations	67.12	San Diego APCD	SCAQMD312-91	SCAQMD309-91	EPA24,25D	ASTMD-1078-86		Existing

Table 4 *Continued*: Survey of Coating Regulations of Districts

Category No.	Rule Title (Exact)	Rule No.	District	Test Method 1	Test Method 2	Test Method 3	Test Method 4	Test Method 5	Status
10	MarineCoatingOperations	67.18	SanDiegoAPCD	EPA24	ASTMD-4457-85	ASTMD-3792-86	ASTMD-3960-87	40CFR60.713	Existing
12	Coatingsandprintinginks manufacturingoperations	67.19	SanDiegoAPCD	EPA18,25, 25A,25D,24	ASTMD-3792-86	ASTMD-2879-83	ASTMD-1078-86		Existing
1	ArchitecturalCoatings	4601	SanJoaqinValley UnifiedAPCD	EPA24,25, 25A,25B	ARB432-422	ASTMD-1613-81			Existing
3	MotorVehicleandMobileEquipment andrefinishingoperations	4602	SanJoaqinValley UnifiedAPCD	EPA24,25, 25A,25B	ARB432-422	ASTMD-1613-81	55FR26865		Existing
2	Surfacecoatingofmetalpartsand products	4603	SanJoaqinValley UnifiedAPCD	EPA24,25, 25A,25B	ARB432-422	55FR26865	ASTMD-1613-81		Existing
5	Canandcoilcoatingoperations	4604	SanJoaqinValley UnifiedAPCD	EPA24,25, 25A,25B	ARB432-422	55FR26865			Existing
6	Aerospaceassemblyandcomponent manufacturingoperations	4605	SanJoaqinValley UnifiedAPCD	EPA24,25,25A, 25B	ARB432	ASTMD-1639-83	ASTM2306-81	40CFR52.741	Existing
7	Woodproductscoatingoperations	4606	SanJoaqinValley UnifiedAPCD	EPA24,25,25A, 25B	ARB432-422	55FR26865			Existing
4	GraphicArts	4607	SanJoaqinValley UnifiedAPCD	EPA24,24A,25, 25A,25C	ARB432	55FR26865	ASTM2306-81		Existing
12	CoatingandInkmanufacturing	4652	SanJoaqinValley UnifiedAPCD	None					Existing
11	Adhesives	4653	SanJoaqinValley UnifiedAPCD	EPA24,25,25A	40CFR52.741				Existing
20	Organicsolvents	4661	SanJoaqinValley UnifiedAPCD	None					Existing
8	Polyesterresinoperations	4684	SanJoaqinValley UnifiedAPCD	EPA24,25,25A	SCAQMD309, 312	ASTMD-2369-87	40CFR52.741		Existing

Table 4 *Continued*: Survey of Coating Regulations of Districts

Category No.	Rule Title (Exact)	Rule No.	District	Test Method 1	Test Method 2	Test Method 3	Test Method 4	Test Method 5	Status
23	Organic materials emission standards, limitations and prohibitions	407	San Luis Obispo County APCD	None					Existing
2	Surface Coating of metals, parts and products	411	San Luis Obispo County APCD	EPA24					Existing
3	Motor vehicle and mobile equipment coating operations	423	San Luis Obispo County APCD	EPA24, 25A, 25B	ASTM D-4457-85	ASTM D-1613-85	SCAQMD 311	55FR 26865	Existing
1	Architectural Coatings	3	San Luis Obispo County APCD						Proposed
10	Marine vessel coatings	10	San Luis Obispo County APCD						Proposed
23	Consumer products	14	San Luis Obispo County APCD						Proposed
11	Industrial adhesive and coatings	15	San Luis Obispo County APCD						Proposed
22	Wood furniture manufacturing	18	San Luis Obispo County APCD						Proposed
18	Plastic parts coatings	29	San Luis Obispo County APCD						Proposed
14	Metal Surface coating thinner and reducer	322	Santa Barbara County APCD	None					Existing

Table 4 *Continued*: Survey of Coating Regulations of Districts

Category No.	Rule Title (Exact)	Rule No.	District	Test Method 1	Test Method 2	Test Method 3	Test Method 4	Test Method 5	Status
1	Architectural Coatings	323	Santa Barbara County APCD	EPA 24					Existing
2	Surface coating of metal parts and products	330	Santa Barbara County APCD	EPA 18, 24, 25, 25A	40 CFR 60.713				Existing
6	Surface coating of aircraft or aerospace parts and products	337	Santa Barbara County APCD	EPA 18, 24, 25, 25A	40 CFR 60.713				Existing
3	Motor vehicle and mobile equipment coating operations	339	Santa Barbara County APCD	EPA 24, 25	ASTM D-4457-85	ARB 100	ASTM 1613-81	SCAQMD 26	Existing
8	Polyester resin operations	349	Santa Barbara County APCD	ASTM D-2369-81	40 CFR 52.741	EPA 25, 25A			Existing
7	Surface coating wood products	351	Santa Barbara County APCD	EPA 24, 25, 25A	55 FR 26865				Existing
4	Graphic Arts	354	Santa Barbara County APCD	EPA 24, 24A, 25, 25A, 18	ARB 432	ASTM D-2306-81	40 CFR 52.741		Existing
None	None	None	Shasta County AQMD	None					N/A
None	None	None	Siskiyou County APCD	None					N/A
10	Marine Coating Operations	1106	South Coast AQMD	EPA 24	SCAQMD 304				Existing
10	Pleasurecraft coating operation	1106.1	South Coast AQMD	EPA 24	SCAQMD 304				Existing
2	Coating of metals parts and products	1107	South Coast AQMD	EPA 24	SCAQMD 304				Existing

Table 4 *Continued*: Survey of Coating Regulations of Districts

Category No.	Rule Title (Exact)	Rule No.	District	Test Method 1	Test Method 2	Test Method 3	Test Method 4	Test Method 5	Status
1	Architectural Coatings	1113	South Coast AQMD	EPA24	SCAQMD 19, 22	SCAQMD 304			Existing
6	Aerospace assembly and component manufacturing operations	1124	South Coast AQMD	EPA24	EPA25, 25A	SCAQMD 25.1	SCAQMD 302, 303, 304		Existing
5	Metal Container, closure, and coil coating operations	1125	South Coast AQMD	EPA24	EPA25, 25A	SCAQMD 25.1	SCAQMD 304		Existing
19	Magnetic wire coating operations	1126	South Coast AQMD	EPA24	SCAQD302, 303, 304				Existing
9	Paper, fabric, and film coating operations	1128	South Coast AQMD	EPA24	SCAQMD 304				Existing
16	Aerosol coatings	1129	South Coast AQMD	EPA24, 24A	SCAQMD 305				Existing
4	Graphic arts, screen printing operations	1130	South Coast AQMD	EPA24, 24A	SCAQD302, 303, 304				Existing
7	Wood products coatings	1136	South Coast AQMD	EPA24	SCAQD302, 303, 304				Existing
17	Control of volatile organic compounds emissions from resin manufacturing	1141	South Coast AQMD	EPA18	EPA25, 25A	SCAQMD 309, 312			Existing
12	Control of volatile organic compounds emissions from coating and ink manufacturing	1141.1	South Coast AQMD	EPA18	EPA25, 25A	SCAQMD 304			Existing
23	Control of volatile organic compounds emissions from surfactant manufacturing	1141.2	South Coast AQMD	EPA18	EPA25, 25A				Existing
18	Plastic, rubber, and glass coatings	1145	South Coast AQMD	EPA24	SCAQMD 304				Existing

Table 4 *Continued*: Survey of Coating Regulations of Districts

Category No.	Rule Title (Exact)	Rule No.	District	Test Method 1	Test Method 2	Test Method 3	Test Method 4	Test Method 5	Status
3	Motor vehicle and mobile equipment non-assembly line coating operations	1151	South Coast AQMD	EPA24	SCAQMD303, 304				Existing
8	Polyester resin operations	1162	South Coast AQMD	EPA18	ARB422	SCAQMD309, 312			Existing
15	Semiconductor manufacturing	1164	South Coast AQMD	EPA24,18	SCAQMD304	25.1	ARB422		Existing
11	Control of volatile organic compound emissions from adhesive applications	1168	South Coast AQMD	EPA18,EPA24	ARB422 SCAQMD316A				Existing
22	Wood flat stock coating operations	1104	South Coast AQMD	EPA24,,25,25A	SCAQMD 304,25.1				Existing
3	Motor vehicle assembly line coating operations	1115	South Coast AQMD	EPA24	SCAQMD302, 303,304				Existing
23	Screen printing operation	1130.1	South Coast AQMD	EPA24,24A	SCAQMD302, 303,304				Existing
None	None	None	Tehema County APCD	None					N/A
None	None	None	Tuolumne County APCD	None					N/A
1	Architectural Coatings	74.2	Ventura County APCD	EPA24	ARB432	ASTM D-1613-85	SCAQMD311-91		Existing
9	Paper, film, and fabric coating operations	74.3	Ventura County APCD	EPA24,18,25, 25A	ASTM432,422, 100	40CFR60.713			Existing
7	Wood products coatings	74.30	Ventura County APCD	EPA24	ARB432	ASTM D-2306-81	40CFR52.741		Existing

Table 4 *Continued*: Survey of Coating Regulations of Districts

Category No.	Rule Title (Exact)	Rule No.	District	Test Method 1	Test Method 2	Test Method 3	Test Method 4	Test Method 5	Status
13	Surfacecleaninganddegreasing	74.6	VenturaCountyAPCD	EPA24,25,25A	ASTMD-4457-85	ASTM1078-78	55FR26865		Existing
2	Surfacecoatingofmetalpartsand products	74.12	VenturaCountyAPCD	EPA24	ASTMD-1613-85	SCAQMD311	ASTMD-2879-86	40CFR52-741	Existing
6	Aerospaceassemblyandcomponent manufacturingoperations	74.13	VenturaCountyAPCD	EPA24,25, 25A,25B	ARB432	ASTMD-1639-83	ASTMD-2306-81		Existing
8	PolyesterResinmaterialoperations	74.14	VenturaCountyAPCD	EPA24,25A	ARB401	ASTMD-4457-85	ASTMD-2369-81	ASTMD-1078-86	Existing
3	Motorvehicleandmobileequipment coatingoperations	74.18	VenturaCountyAPCD	EPA24,25A	ASTMD-4457-85	ASTMD-1613-85	ASTMD-2306-81	SCAQMD-26	Existing
4	GraphicArts	74.19	VenturaCountyAPCD	EPA24,24A, 25,25A,18	ARB432	ASTMD-2306-81	40CFR52.741		Existing
11	Adhesivesandsealants	74.2	VenturaCountyAPCD	EPA24	ASTMD-4457-85	SCAQMD305, 316A	ASTME260-91	ASTMD-2879-86	Existing
15	Semiconductomanufacturing	74.12	VenturaCountyAPCD	EPA24,25,18	ARB432	ASTME260-91	ASTMD-2879-86	40CFR52-741	Existing
20	Organicsolvents	2.13	Yolo-SolanoCounty AQMD	ASTME168-67, E169-87,E	ASTMD2879-86	40CFR52.741	EPA25A		Existing
1	ArchitecturalCoatings	2.14	Yolo-SolanoCounty AQMD	None					Existing

Table 4 *Continued*: Survey of Coating Regulations of Districts

Category No.	Rule Title (Exact)	Rule No.	District	Test Method 1	Test Method 2	Test Method 3	Test Method 4	Test Method 5	Status
2	Metal parts and products coating operations	2.25	Yolo-Solano County AQMD	EPA 24, 25A	ASTM D 4457-85	ASTM D 1613-85	SCAQMD 311	40 CFR 52.741	Existing
3	Motor vehicle and mobile equipment coating operations	2.26	Yolo-Solano County AQMD	EPA 24, 25	40 CFR 52.741	SCAQMD 311	ASTM D 1613-85		Existing
4	Graphic sarts printing operations	2.29	Yolo-Solano County AQMD	EPA 24, 24A, 25	ASTM D 4457-85	ARB 432	40 CFR 52.741	SCAQMD 311	Existing
8	Polyester resin operations	2.30	Yolo-Solano County AQMD	EPA 24, 25A, 18	ASTM D-3960-81	ASTM 1078-86	ARB 401	40 CFR 52.741	Existing
13	Surface preparation and clean-up	2.31	Yolo-Solano County AQMD	EPA 24, 25, 25A, 18	ASTM D 2879-86	40 CFR 52.741			Existing
11	Adhesive operations	2.35	Yolo-Solano County AQMD	EPA 24, 25, 25A	40 CFR 52.741				Existing

III

Identification of Test Method Problems

1. Survey Test Method Evaluation

In order to get the benefit of the knowledge and experience of the people involved in actually using and developing test methods, we prepared a second survey letter to be sent to the federal, state, and local government agencies and private agencies and testing laboratories involved in performing and developing test methods for VOC emissions from coatings and coating operations. The letter, Survey A2, consisted of a cover letter describing the project goals and a request for assistance in identifying problems with current test methods for VOC emissions from coatings and coating operations which we had identified. We asked them to identify any test methods we had omitted, and to comment on current test methods. We deliberately left the request for comments on current test methods completely open, in order to obtain both positive and negative comments regarding existing methods.

This survey on test methods was sent to scientists at government (federal, state, and local) and private analytical testing laboratories. The recipients had been identified from the previous survey, and from discussions with personnel at national (EPA, ASTM, NIST), state (ARB) and local agencies involved in development and implementation of test methods for VOC emissions from coatings and coating operations. The list (Table A3) is composed of individuals involved with test methods for coatings and coating operations and includes over 100 names, most of which came from the membership roster for ASTM Subcommittee D01.21 (Chemical analysis of paint and paint materials, Hiroshi Fujimoto, Chairman).

Since it was impractical to survey such a large group, we selected 28 individuals on the basis of recommendations from the staff at ARB and EPA, and from Dr. Fujimoto, the chairman of the ASTM committee. Some of the individuals surveyed were selected because of articles they had published relating to the subject of test methods for VOC emissions from paints. Finally, several names were obtained by calling analytical laboratories throughout the state and asking if they performed any of the test methods for coatings and coating operations. However, this method was not very efficient, since it appears that very few analytical laboratories in California perform any of the test methods for paints or other coatings.

The response to the test method survey was very good (20 of 28, 71.4%), with several of the individuals responding with detailed, multi-page letters. Table 6 identifies those individuals to whom this survey was sent. The response from Dr. William Golton was particularly valuable, since he has many years of experience in test methods for VOC emissions from paints, and he is currently one of the instructors in the ASTM workshops on VOC in paints.

2. Literature Survey of Test Method Problems

In parallel to the surveys which we conducted of the district rules and regulations and the test methods related to coatings and coating operations, we also conducted a thorough computer library and database search. In addition to obtaining information on all regulations and testing methods relating to VOC emissions from coating operations, this study was also able to acquire a listing of names and organizations (universities, public or private labs) which have been involved in the development or performance of testing methods for the associated coating categories.

Table 6: CONTACTS SURVEYED FOR TEST METHODS

Contact 1	Facility	Phone No.	Address	Survey Form Sent	Survey Form Received
Rudy Zerrudo	BAAQMD	(415) 749-4629	939 Ellis Street San Francisco, CA 94109	Yes	Yes
Cory Choa	SACAQMD	(909) 396-2172	21865 E. Copley Drive Diamond Bar, CA 91765	Yes	Yes
Ed Jeung	E. H. S. Air and Industrial Hygiene Labs	(510) 540-2814	2151 Berkeley Way Berkeley, CA 94704	Yes	Yes
Pete Kosel	ARB	(916) 263-2051	PO Box 2815 Sacramento, CA 95812	Yes	Yes
D. Patrick Fairley	Calcoast Analytical Labs	(510) 652-2979	4072 Watts Street Emeryville, CA 94608	Yes	Yes
Robert D. Athey, Jr.	Athey Technologies	(510) 526-3541	P.O. Drawer 7 El Cerrito, CA 94530-0007	Yes	Yes
Rita Baggs, Dr.	American Research and Testing, Inc.		4934 S. Figueroa Street Gardenn, CA 90248	Yes	No
Jacob Nercessian	Certified Testing Laboratories, Inc.	(310) 424-9992	2648 East 28th Street Signal Hill, CA 90806	Yes	Yes
Hiroshi Fujimoto	Advanced Technologies of Michigan	(810) 788-9707	Livonia, MI 48150	Yes	Yes
Sites Mary E. MS	W R Grace & CO, Dewey & Almy Chemical Division	(617) 861-6600	55 Hayden Ave Lexington, MA 02173	Yes	Yes

Table 6 *Continued*: CONTACTS SURVEYED FOR TEST METHODS

Contact 1	Facility	Phone No.	Address	Survey Form Sent	Survey Form Received
Dr. Joe Benga	PPG Industries	(412) 492-5511	4325 Rosanna DR P.O. Box 9 Allison Park, PA 15101	Yes	Yes
Dr. William C. Golton	DU Pont-Merck Pharma	(610) 543-0395	509 Beatty RD Springfield, PA 19064	Yes	Yes
R. K. M. Jayanty	Research Triangle Institute	(919) 541-7026	P.O. Box 12194 Research Triangle Park, NC 27709	Yes	Yes
Gary McAlister	E. P. A.	(919) 541-1062	Research Triangle Park, NC 27709	Yes	Yes
Dean Berger	Berger Associates, Inc.	(717) 656-6296	Box 56 Leola, PA 17540-0056	Yes	No
Glenn Jackson, Sr.	Special Services Group Bowser Morner		4518 Taylorsville Road Dayton, OH 45401	Yes	No
Jerry H. Willner	DL Laboratories	(212) 777-4410	116 East 16th Street New York, NY 10003	Yes	Yes
Ron J. Wingender,	Dexter Corporation		1 East Water Street Waukegan, IL 60085	Yes	Yes
Dr. Shari Thannidar	Chemir/Polytech Labs	(800) 659-7659	2672 Metro Building St. Louis, MO 63043	Yes	Yes

Table 6 *Continued*: CONTACTS SURVEYED FOR TEST METHODS

Contact 1	Facility	Phone No.	Address	Survey Form Sent	Survey Form Received
Doug Ezell	TSL Inc. Labs	(417) 864-8924	1512 North Lexington Springfield, MO 65802	Yes	Yes
Gary Cox	1T1 Anti-Corrosion, Inc.	(713) 771-0688	10175 Harwin, NO. 110 Houston, TX 77036	Yes	Yes
Carol Morrison	Galbraith Laboratories, Inc.	(615) 546-1335	2323 Sycamore Drive Knoxville, TX 37921	Yes	Yes
William J. Simonsick,	E. I. DU Pont DE Nemours Corporation, Automotive Products, Marshall R & D Labs		P.O. Box 3886 Philadelphia, PA 19146	Yes	No
David P. Sheih	Dow Chemical Co.		Freeport, TX 77541	Yes	No
Theodore Provder	The Glidden Co. Research Center		16651 Sprague Road Strongsville, OH 44136	Yes	No
A. Monroe Snider, Jr.	PPG Industries, Inc.		Pittsburgh, PA 15238	Yes	No
Francis X. Young,	Sherwin-Williams Co.		Cleveland, OH 44113	Yes	No
Max T. Wills	California Polytechnic State Univ.	(805) 756-2746	Chemistry Department San Luis Obispo, CA 93407	Yes	Yes

The library and database search was conducted using the facilities at the University of California, Davis library, including the Melvyl Library system (which provides access to the entire resources of all the University of California libraries), the library CD-ROM network, and the government documents collections. In addition, the use of on-line database services, including the Internet and the on-line Chemical Abstracts Service were used. The Air Resources Board library was also utilized. The database search included, but was not limited to the databases and systems listed in Table A4.

The databases were subsequently searched using the title-word format. If no citations were found using this format, then an alternate key-word format was implemented. In most instances, title-word was determined to be the most effective method for obtaining article citations, using the prescribed search strategy format. The search strategy format incorporated specific search terms into an algorithm, thus enabling a more systematic means of literary surveying to be conducted. Table A5 identifies the search terms utilized, and outlines the unique search strategy.

Information obtained from searches conducted through the Internet were facilitated with the use of web browsers such as Netscape and Mosaic. The general goal of searching the Internet was to locate information relating to VOC's, coatings, coating operations and methods of testing for VOC's in coatings and coating operations, that might not be readily found in standard databases. The search strategy incorporated initial search terms (e.g. environment, EPA, government regulations) followed by terms (e.g. coatings, coating operations, VOC , methods of testing for VOC's) more specific in content to the subject matter being sought. This search strategy enabled us to systematically narrow the specific search terms resulting in a refined method

of searching the Internet. Searching the Internet was facilitated by "search engines" such as Infoseek, Lycos, and Alta Vista. Table A6 is a listing of Internet addresses that were searched for specific information relating to VOC's, coatings, coating operations and methods of testing for VOC's in coatings and coating operations.

Documents and articles obtained through the library and computer database search resulted in more than 150 articles relating to the emissions of VOC's, development of testing methods for VOC coatings, analysis of organic coatings, and EPA regulations. Cross referencing of articles was expected and documented, indicating that searches were overlapping on the various databases as well as over various search terms. This overlapping verified the effectiveness of the search strategy. The effectiveness of this algorithm has also been verified by a search conducted through the CAS (Chemical Abstracts Service), which covers worldwide literature from all areas of chemistry, biochemistry and chemical engineering—including subject areas involving organic, inorganic, physical and analytical chemistry. The CAS incorporated over 9000 journals, patents from 25 countries, conference proceeding reviews, technical reports, books and dissertations, with files dating back to 1967.

IV

Analysis of Test Method Problems

1. Introduction

The test methods for determining VOC emissions from coatings and coating operations can be divided into several general categories. The first category, exemplified by EPA Reference Method 24, consists of laboratory analytical methods which have been developed by government agencies and private organizations such as ASTM to determine the physical and chemical characteristic of paints, inks, varnishes, and other industrial and commercial coating products. While the overall purpose of these test methods is to determine the VOC content of the coating, most of the methods actually test for other properties such as water content, coating density, total volatile content, volume nonvolatile matter, etc. and the VOC content is calculated indirectly from these other measurements.

The second category of test methods, exemplified by EPA Reference Methods 25 & 25A, includes source test methods designed to measure VOC emissions from commercial coating operations such as paint spray booths, can and coil coating lines, graphic arts printing operations, etc. These methods do involve the direct measurement of VOC content of the exhaust air and fugitive emissions from commercial coating operations.

A third category of test methods involves attempts to determine the transfer efficiency of coating operations, particularly those using spray-coating techniques. The transfer efficiency is defined as the ratio of the amount of paint solids deposited onto the surface of the coated part to the amount of coating solids used. While the concept of transfer efficiency is simple and easily understood, measuring it even under controlled conditions is complicated and difficult.

2. Laboratory Test Methods

The laboratory methods, such as EPA Method 24, have served extremely well in the applications for which they were developed--determining the VOC content of traditional solvent-based, high-VOC coatings. As a result of these methods, and the federal, state, and local regulations based on them, VOC emissions from paints and other coatings have been dramatically reduced over the past 25 years (Kirschner, 1994).

However, the success in reducing the VOC content of coatings has created problems with Method 24 itself, due to the indirect way in which it calculates VOC content from other measurements. Basically, Method 24 defines VOC content as:

$$VOC\ Content = \frac{(total\ volatile\ content) - (water\ content) - (exempt\ solvent\ content)}{(1 - (water\ fraction) - (exempt\ solvent\ fraction))100\%}$$

It is obvious from this equation that as VOC content gets smaller and water content and exempt solvent content get larger (which is true for many new coatings), then the calculated VOC concentration becomes extremely unreliable, primarily due to the subtraction terms in the denominator. It is even possible to calculate negative values for the VOC concentration of low solvent-high water content coatings. These problems exist even if the individual measurements used to calculate VOC content are done with very high precision. For VOC concentrations below 100 g/L, the experimental error is often larger than the calculated value (Brezinski, 1993).

It would be possible to avoid some of these problems by calculating VOC content based upon the mass of VOC per unit volume of coating solids. However, this requires the measurement of volume percent of nonvolatile

content of the liquid coating. The ASTM method for measuring this quantity (Test Method D-2697) is neither approved nor recommended by the EPA, and current EPA policy requires that volume nonvolatile matter be calculated on the basis of formulation data from the manufacturer (Brezinski, 1993). There is currently a new method for determining volume nonvolatile content being tested, involving the use of a helium pycnometer. The preliminary results of the testing indicate that the method has the potential for high precision measurements, and may be a solution to the problem of measuring volume nonvolatile content of paints and other coatings.

However, even if the helium pycnometer does solve the problem of measuring volume nonvolatile content, there would still be a problem in determining VOC content as the difference between total volatile content and water content (and exempt solvent content). Basically, this is the old problem of a small difference in large numbers, and it is inherently unstable and inaccurate.

There are ongoing efforts (Ancona et. al., 1993; Jenkins et. al., 1995, Golton, 1995; Fairley, 1991; and Ferlauto, 1988) to improve the precision and accuracy of many of the individual ASTM methods which make up Method 24. However, even if the individual methods used in the VOC calculation all provide very precise data, the indirect method by which VOC concentrations are currently calculated does not work for low-VOC, high water-content coatings.

A round-robin study was conducted by ASTM in 1990 involving 14 Laboratories performing the tests required by EPA Method 24 (and ASTM D 3960) (Brezinski, 1993). Despite an interlaboratory reproducibility of better than 5% on each test, the interlaboratory reproducibility for the VOC calculations using the above equation was 54.4% for coatings containing 60-

70% water and approximately 100g/L VOC. In comparison, the interlaboratory reproducibility for a solvent-based coating was 2.9%.

There is also the problem of determining exempt compounds, which requires separate analyses for each class of exempt compounds which might be present in a coating. There are already a large number of exempt compounds (primarily chlorinated and fluorinated hydrocarbons), and the recent recommendation by the EPA that acetone be classified as an exempt compound will require an additional analysis specifically for it. In addition, there is the possible use of ammonia as a solvent in coatings. Under the current test methods, ammonia would be calculated as a VOC, and therefore would produce erroneously high VOC values, unless a separate analysis were performed to measure it.

It would be much better for this category of coatings (low-VOC, high water-content) to obtain a direct measurement of VOC content rather than continue to calculate it as the difference between total volatile and water content (and exempt compounds).

There is also the need for a method to measure hazardous air pollutants (HAPs) in paints and other coatings. EPA has recently proposed a new Method 311, "Analysis of HAP compounds in paints and other coatings by direct injection into a GC." However, this method appears to have a number of drawbacks, including the use of a thermal conductivity detector, which is non-specific and has very poor sensitivity relative to other GC detectors (i.e. FID, PID, ECD, TID, AED, and MS). Several ASTM sub-committees are currently investigating the use of GC and GC-MS for the analysis of VOCs and HAPs in paints and other coatings (Fujimoto, 1995). SCAQMD uses their method 304 for HAPs and VOC of materials that contain < 50g/L VOC. It would appear that cooperation and collaboration with the

ASTM groups currently engaged in this research would be the most effective approach to developing new test methods for low-VOC, high water-content coatings.

In addition to recommending cooperation and collaboration with ASTM, a related issue should be mentioned: the necessity to update the methods cited in the district regulations and EPA methods. Most of the ASTM methods cited in district regulations are outdated, sometimes by more than a decade, while EPA method updates are published haphazardly in the Federal Register, with current versions and proposed changes also made available on the EMTIC bulletin board. The continuous revision process makes it possible for different versions to be available on the EMTIC bulletin board, current annual CFR books, and in the Federal Register. Some form of coordination between ASTM, EPA, and perhaps the ARB should be initiated in order to establish a single, official location (such as the EMTIC bulletin board) where the latest approved methods would be collected and made available to everyone, including districts, laboratories, etc. It follows that district regulations should be written to specify the latest approved version of a test method, rather than a specific version which may be 15 years out of date in current regulations.

3. Source Test Methods

The second category includes such methods as EPA Methods 25 & 25A. These methods are concerned with directly measuring the VOC emissions from industrial and commercial operations such as automobile assembly plants, auto body refinishing shops, can and coil coating lines, commercial printing plants, etc. These methods have two components, the sampling train and the analytical method. Recent studies of VOC emission measurement methods, including EPA Methods 25, 25A, and others have

shown that even under controlled, laboratory conditions the methods exhibit poor accuracy and precision, particularly with regard to polar organic compounds such as aldehydes, ketones, and alcohols (Eklund and Nelson, 1995). The results of a series of tests are summarized in Table 7 for each test method at each test condition. The accuracy of the measurements for all methods is very poor, with the measured VOC concentration being far too high at low VOC levels (11-13 ppmv), and too low (often by more than 50%) at higher VOC levels. The precision of the measurements was better than the accuracy, indicating that the methods are better suited to measuring changes in emission levels over time, rather than for measuring the absolute magnitude of emissions.

These results were obtained using an artificial test apparatus constructed in the laboratory. The situation in a real commercial or industrial facility can be expected to be much worse. In fact, the problems of sampling VOC emissions from an operation such as a can and coil coating line (containing alderhydes and ketones) can be considerable, especially if the test apparatus utilized in the laboratory study bears little relation to a real world situation. This would appear to indicate that the situation with regard to source test methods for VOC emissions from coating operations is in need of attention. Both the specific methods and the overall approach to measuring VOC emissions from coating operations need to be given thorough scrutiny. It would appear that new, innovative approaches need to be developed. At the present time, most air pollution control and air quality management districts in California use a mass balance approach to calculating source emissions rather than any of the existing source test methods.

Table 7: SUMMARY OF TEST RESULTS

TestMethod		THC (ppmv): 11-13 RH: 80%	172-249 79%	525-785 79%	168-248 22%
Portable Analyzers					
1. OVA Model 108	Number of Data Points	6	6	6	6
	Mean of Set (ppmv)	33.33	140.50	377.83	134.83
	Average Accuracy (%)	198	-19	-29	-25
	Standard Error at 95% C.I.	1.71	5.38	44.05	4.57
	CV (%)	4.9	3.7	11.1	3.2
2. HNU Model 101A	Number of Data Points	6	6	6	7
	Mean of Set (ppmv)	7.97	34.33	64.33	25.57
	Average Accuracy (%)	-29	-80	-88	-84
	Standard Error at 95% C.I.	0.32	1.43	10.34	1.36
	CV (%)	3.9	4.0	15.3	5.1
Total Hydrocarbon Analyzers					
3. EPA Method 25A (Beckman)	Number of Data Points	24	21	20	28
	Mean of Set (ppmv)	21.63	102.14	303.92	100.78
	Average Accuracy (%)	83	-48	-49	-47
	Standard Error at 95% C.I.	0.54	2.28	6.45	0.91
	CV (%)	5.9	4.9	4.5	2.3
4. EPA Method 25	Number of Data Points	6	6	6	6
	Mean of Set (ppmv)	40.23	52.37	106.13	28.43
	Average Accuracy (%)	266	-76	-84	-64
	Standard Error at 95% C.I.	79.64	48.45	59.11	12.31
	CV (%)	188.7	88.2	53.1	41.3
5. Modified EPA Method 25 (Byron)	Number of Data Points	5	5	6	6
	Mean of Set (ppmv)	33.00	114.60	344.50	98.33
	Average Accuracy (%)	179	-36	-37	-45
	Standard Error at 95% C.I.	4.73	9.16	8.82	29.04
	CV (%)	11.5	6.4	2.4	28.2
Byron-Direct Injection (EPA Method 25A)	Number of Data Points	5	6	6	6
	Mean of Set (ppmv)	29.60	130.83	366.67	111.67
	Average Accuracy (%)	150	-27	-33	-37
	Standard Error at 95% C.I.	1.42	2.14	5.42	1.71
	CV (%)	3.9	1.6	1.4	1.5
Air Sample Collection Methods					
6. Canister/GC-FID	Number of Data Points	5	6	3	N/A
	Mean of Set (ppmv)	80.00	287.83	447.00	N/A
	Average Accuracy (%)	584	23	-36	N/A
	Standard Error at 95% C.I.	33.6	239.99	25.22	N/A
	CV (%)	33.8	67.1	2.9	N/A
7. Charcoal Tube/GC-FID	Number of Data Points	6	6	6	6
	Mean of Set (ppmv)	57.32	200.83	440.17	198.17
	Average Accuracy (%)	331	-19	-44	-20
	Standard Error at 95% C.I.	25.27	34.72	29.30	49.16
	CV (%)	42.0	16.5	6.3	23.6
8. XAD-2 Tube/GC-FID	Number of Data Points	6	6	6	6
	Mean of Set (ppmv)	59.00	250.50	400.50	218.00
	Average Accuracy (%)	340	0.6	-49	-11
	Standard Error at 95% C.I.	3.55	12.67	20.35	40.48
	CV (%)	5.7	4.8	4.8	17.7

Source: Eklund and Nelson, 1995

One of the major problems in source test methods has to do with the EPA capture efficiency protocols, and their requirement for a temporary or permanent total enclosure around the coating process to be tested. Since multiple coating processes may exist in a single plant building, and these may be connected by assembly lines, it is extremely difficult to enclose each process individually, and using the entire building as an enclosure makes it impossible to measure the emissions from each process individually. One possible approach would be the use of integrated samples, which could be collected at strategic locations throughout the building for subsequent analysis by either a GC-multiple detector or a GC-MS (Wadden, et. al., 1995a,b). Inert tracers could be used to differentiate the sources, or compounds specific to particular processes could be used (i.e. source-receptor modeling) (Davoli, et. al., 1993). The added cost of the analyses would be more than compensated for by the elimination of the need for enclosures, which are expensive, interfere with the efficient operation of the plant, and are potentially hazardous. The SQAQMD Capture Efficiency Protocol is also an recognized method used for compliance purposes. They have demonstrated that their protocol is equivalent to EPA's total enclosure method.

4. Transfer Efficiency Estimates

Test methods for transfer efficiency have been developed, such as ASTM D-5066 (Transfer efficiency under production conditions: Automotive coating process), and ASTM D-5009 (Transfer efficiency: Evaluating and comparing under laboratory conditions). However, while these methods showed relatively good intralaboratory repeatability, the agreement between different laboratories was very poor (Brezinski, 1993). The results are known to be dependent on the air flow in the paint spray booth, the rate at which the paint is delivered, and a number of other variables (including the spray gun

operator). These test methods for transfer efficiency are more useful for research purposes, for the evaluation and comparison of different techniques and equipment. They provide only the direction of the effects of different variables on transfer efficiency, and only under the specific conditions of the laboratory test. Since there are many different variables affecting transfer efficiency, the extrapolation of the laboratory test results to commercial coating lines is not possible.

Obviously, the test methods for transfer efficiency in coating operations need to receive further study. Although there is a strong economic incentive for companies performing coating operations to improve transfer efficiency, the labor costs often outweighs material costs. Thus it may still be necessary for government agencies to regulate transfer efficiency. Transfer efficiency is currently not included in the federal regulations regarding VOC emissions from coating operations, and so none of the test methods for transfer efficiency are currently used for calculating VOC emissions factors.

5. Test Method Development

When the current laboratory test methods (such as EPA Method 24) were developed a generation ago, the analytical instrumentation available was considerably different from today, particularly with regard to gas chromatography-mass spectrometry (GC-MS). At that time GC-MS was almost exclusively a research technique, and very few commercial laboratories utilized it except for specialized analyses such as for dioxin. There has also been considerable development of other detectors for gas chromatography, such as the photo-ionization detector (PID), electron-capture detector (ECD), thermionic ionization detector (TID)(Mitra, et al., 1995), and atomic emission detector (AED)(Schafer, 1993), which provide very sensitive and specific analyses for a variety of organic compounds.

There are currently several task groups of ASTM Subcommitte D01.21 (Chemical Analysis of Paints and Paint Materials) investigating the use of gas chromatographic techniques for the analysis of VOCs and HAPs in paints and other coating materials. The most promising approach appears to be the work of the group "Hazardous Air Pollutants (HAPs) in Paints by Headspace/Gas Chromatography/Mass Spectrometry". There are a number of advantages to using headspace analysis rather than direct injection of samples into the gas chromatograph. First, by keeping the volatilization process separate from the gas chromatographic analysis, the method can follow the current EPA Method 24 test conditions (heating at 110 C for one hour) or any other test conditions which may be required, including the use of UV radiation to cure coatings. There is also less chance of decomposition, since the high injection port temperatures (250 C) required by direct injection are not necessary. Headspace analysis also makes it possible to measure VOCs and HAPs from powder coatings, fast cure multi-component paints, and other coatings which cannot be directly injected into a GC.

There are some drawbacks in the static-headspace approach which is currently being used by the ASTM group, since the VOCs and HAPs are in equilibrium with the nonvolatile matrix, and therefore different compounds may have different relative response ratios, depending upon exact nature of the matrix and the equilibrium temperature. It would appear that a dynamic-headspace technique would be preferable, since it would be able to strip all of the VOCs and HAPs from the sample for an absolute, quantitative determination. A dynamic-headspace technique would require some method of sample collection prior to injection of the sample into the GC, but there are a number of potential methods available, including the use of multi-sorbent

traps (McClenny, et al., 1995), cryogenic trapping, and chemical derivitization for analysis of specific compounds.

There has not been as much attention paid to new method development for source test methods for VOC emissions. However, the results of the study by Eklund and Nelson (1995) suggest possible incentives to develop new source test methods for VOC emissions. Their results show accuracy and reproducibility problems among the current test methods, and the cost and inconvenience of using total temporary enclosures (TTEs) for measuring fugitive VOC emissions. The South Coast District is developing a low VOC method that holds promise for detecting concentrations below 5 ppm.

One promising approach for determining VOC emissions from coating operations has been investigated by Wadden et al.(1995a,b). They used the building shell as the test enclosure, and measured air flow rates and VOC concentrations at each air entry and exit point. Samples were collected simultaneously at all locations over 12 one-hour periods, using adsorbent tubes, and were analyzed by GC for total VOC and up to 19 individual compounds. They were able to determine VOC emissions rates from 3 different offset printing plants without using a TTE, and without interfering with worker's activities, increasing worker exposure to air pollutants and noise, or increasing safety and explosion hazards, all potential problems with the use of TTEs.

This general approach of collecting integrated samples at strategic locations throughout the building for subsequent analysis by GC appears to be one that should receive further testing. There are a number of possible improvements to the method of Wadden et al. (1995a,b) which should be investigated, including the use of different sorbents (McClenny, et al., 1995) or

integrated canister samples, the use of new sampling techniques such as solid phase microextraction (Zhang & Pawliszyn, 1993), and the use of inert tracers and source-receptor modeling to differentiate sources from different processes located within a single building.

The sampling and analytical techniques and source-receptor models for data analysis of VOC emissions have been extensively developed for use in ambient air, where the use of TTEs was never a possibility. Therefore, there are well developed and validated methods for sample collection and analysis for VOCs, and for source-receptor analysis of the VOC measurements. These methods should be considered when developing new source test methods for VOC emissions from coating operations.

V

Ranking of Test Method Problems

1. Telephone Conference on Test Method Problems

The final task of the project to survey test methods and method development for VOC emissions from coatings and coating operations is the ranking of the test method problems identified in the previous section. The test method problems were identified by a combination of extensive research into the scientific and technical literature, a series of surveys sent to scientists and officials at local, state, and federal air pollution agencies and private laboratories and consulting firms, and direct correspondence and conversations with individual scientists and officials.

As a result of the literature research and the responses and ideas of many scientists and officials directly involved in implementing test methods for VOC emissions from coatings and coating operations, we prepared a series of position papers on the problems we had identified with the test methods. These position papers, which represented our developing understanding of the test method problems for VOC emissions from coatings and coating operations, were circulated to selected individuals who had responded to our previous surveys.

We prepared three versions of our position paper on test method problems, each successive version incorporating the comments and ideas of the scientists and officials who had reviewed the previous version. The third version was prepared for the telephone conference with the air pollution control and air quality management districts, and was sent to all the participants prior to the conference. An agenda for the telephone conference was also sent to the participants, in order to insure that all of the major topics were discussed, given the time constraints of the conference (Table 8).

The conference was organized by the personnel of the California Air Resources Board, and was held on October 17, 1995. A list of the participants is given in Table 9. The five districts who participated (Bay Area AQMD, Sacramento Metropolitan AQMD, San Diego County APCD, San Joaquin Valley Unified APCD, and the South Coast AQMD) represent areas comprising more than 80% of the population of California, and encompassing all of the regulatory categories for VOC emissions from coatings and coating operations we identified in Table 1.

2. Ranking of Test Method Problems/Results of Telephone Conference

The participants in the telephone conference were virtually unanimous in their agreement on the number one problem with current test methods for VOC emissions from coatings and coating operations: the inability of EPA Method 24 (and related ASTM and district methods) to provide accurate results for coatings containing low VOC and high water content. The current methods cannot be used with confidence for water-borne coatings containing VOC < 100 g/L. The problem is not primarily with the analytical techniques involved, but with the method of calculating the VOC concentration (as described in the previous section). Additional problems with EPA Method 24 and related methods were mentioned regarding high solids, multi-component coating mixtures, and with the proposed exemption of acetone, and the use of ammonia as a solvent.

The problems with EPA Method 24 and related methods are not amenable to improvements in the various analytical techniques involved. The existing analytical techniques are already extremely accurate. The primary problem is the method of calculating VOC content using the formula:

$$VOC\ Content = \frac{(total\ volatile\ content) - (water\ content) - (exempt\ solvent\ content)}{(1 - (water\ fraction) - (exempt\ solvent\ fraction))100\%}$$

Table 8: TELEPHONE CONFERENCE AGENDA

Topic: Telephone Conference on VOC Test Method Problems with ARB/UCD/District Representatives

Location: ARB Conference Room CN1, Sacramento.
Telephone No.: (916) 327-1528

Date: Tuesday, October 17, 1995

Time: 1:30-3:30

Agenda:

Laboratory Test Methods (EPA Method 24)

1. General problems with low-VOC (<100 g/L)coatings
2. Specific problems with current methods for all coatings
   (a) Volume nonvolatile matter (ASTM d 2697)
   (b) Water content (ASTM D 4017 & D 3792)
   (c) Multi-component and high solids coatings (ASTM D 2369)

Source Test Methods

1. EPA Method 25
2. EPA Method 25A
3. Other source test methods (portable analyzers, canisters, tubes)

Transfer Efficiency Test Methods

(No current accepted methods)

Support Test Methods

***Phone calls placed to District Representatives between 1:20 and 1:25 PM**

Table 9: Telephone Conference Participants

Name	Organization
David Pierotti	University of California, Davis
Brian Higgins	University of California, Davis
Robert Grant	California Air Resources Board
Pete Kosel	California Air Resources Board
Cindy Castronovo	California Air Resources Board
Rudy Zerrudo	Bay Area AQMD
Cleophina David	Bay Area AQMD
Gary Fend	Bay Area AQMD
Kevin Leonard	Sacramento Metropolitan AQMD
Pat Tedeschi	Sacramento Metropolitan AQMD
Natalie Zlotin	San Diego County APCD
Clint Cooney	San Diego County APCD
Raj Atwal	San Joaquin Valley Unified APCD
Corie Choa	South Coast AQMD
Glenn Kasai	South Coast AQMD

Therefore, it appears necessary to develop a new, direct method for determining the VOC content of coatings which can be used for low VOC, high water-content coatings. The use of a direct method would address a number of problems in addition to the problem with low VOC coatings, including the proliferation of exempt compounds, the need to measure hazardous air pollutants (HAPs), and the proposals to base ozone control strategies on the atmospheric reactivity of individual VOCs, rather than the total VOC content (Russell, et. al., 1995, Bergin, et. al., 1995).

There was not general agreement on any other particular problem with current test methods. Specific problems with source test methods such as EPA Methods 25 and 25A were discussed. Considerable criticism was made of the expense of the methods, particularly with regard to measurements of capture efficiency. It was generally agreed that capture efficiency is routinely calculated using a mass balance approach, rather than by making direct measurements.

Given the reluctance to use Method 25, 25A due to their expense, and the poor accuracy they have shown in recent laboratory tests (see for example Eklund and Nelson, 1995), it would appear that consideration should be given to developing new source test methods, including the use of integrated samples and source-receptor analysis (Wadden, et. al., 1995a, 1995b).

Finally, with regard to test methods for transfer efficiency, there was general agreement that the methods are useful primarily for a relative ranking of equipment, rather than for establishing an absolute transfer efficiency number. It was agreed that it is impractical to measure transfer efficiency under real conditions. For example, one can get an average T.E.

over extended periods by measuring gallons of coating used over , say, one week, instead of a few ounces.

A list were then prepared that identified test methods with problems. It is important to recognize that if a test method is not listed below (see Table 4 for a complete listing of test methods), then no conclusion should be drawn other than it was not identified to have significant problems.

List A: Test Methods Identified with Significant Problems

In the following list, the test method problem is described, and the importance of the problem is categorized in terms of relative importance, magnitude of errors, cost of current method, importance assigned by districts, and other considerations. These categories are used later for ranking the problem. At this stage of the ranking procedure, the qualitative qualifiers "large", "moderate" etc. are used.

Test Method: EPA Method 24 and ASTM D 3960: Determination of Volatile Matter Content, Density, Volume Solids, and Weight Solids of Surface Coatings

Problem:

Calculation of VOC for low-VOC, high-water-content coatings using the "minus water equation" gives extremely poor precision and accuracy, regardless of the precision and accuracy of the individual test methods used to provide the data for the calculation.

Importance of Problem:

Relative importance: Affects all low-VOC, high water-content coatings
Magnitude of errors: Very large
Cost of current method: Increasing with complexity of test method
Importance assigned by districts: Very high
Other considerations: Other problems associated with method 24

Overall importance: Very high

Resolution effort:

Develop new method using direct determination of VOC. Collaborate with ASTM in testing and validation of method.

Estimated cost of resolution effort: $150,000-200,000

Test Method: EPA Method 24 and ASTM D 3960: The Determination of Volatile Matter Content, Density, Volume Solids, and Weight Solids of Surface Coatings

Problem: Not appropriate for UV-cured coatings

Importance of problem:

Relative importance: Affects all UV-cured coatings
Magnitude of errors: Large
Cost of current method: Not applicable
Importance assigned by districts: Low-Moderate
Other considerations: Other problems associated with Method 24

Overall importance: Moderate

Resolution effort:

EPA has added ASTM D 5403 Test Method for Volatile Content of Radiation Curable Materials to EPA Reference Method 24.

Estimated cost of resolution effort: None

Test Method: EPA Method 24 and ASTM D 3960: The Determination of Volatile Matter Content, Density, Volume Solids, and Weight Solids of Surface Coatings

Problem: Ammonia present in coatings is included in VOC calculations.

Importance of problem:

Relative importance: Affects coatings containing ammonia
Magnitude of errors: Small-Moderate
Cost of current method: Not applicable
Importance assigned by districts: Low-Moderate
Other considerations: Ammonia emissions can be toxic.
Overall importance: Low-Moderate

Resolution effort:

Development of direct method to measure VOC would eliminate problem. Addition of ammonia measurement to existing Method 24 would make Method 24 more inaccurate and imprecise, regardless of the accuracy of the ammonia measurements.

Estimated cost of resolution effort: None (if direct method is developed)

Test Method: EPA Method 24 and ASTM D 3960: The Determination of Volatile Matter Content, Density, Volume Solids, and Weight Solids of Surface Coatings

Problem: Exemption of acetone will affect VOC calculation.

Importance of problem:

Relative importance: Affects coatings containing acetone. It is expected that many coatings will be reformulated to use acetone under the exemption.
Magnitude of errors: Potentially Large
Cost of current method: Not applicable
Importance assigned by districts: Moderate -High
Other considerations: Acetone emissions can be toxic

Overall importance: Moderate-High

Resolution effort:

Development of direct method to measure VOC would eliminate problem. Addition of acetone measurement to existing Method 24 would make Method 24 more inaccurate and imprecise, regardless of the accuracy of the acetone measurements.

Estimated cost of resolution effort: None (if direct method is developed)

Test Method: EPA Method 24 and ASTM D 3960: The Determination of Volatile Matter Content, Density, Volume Solids, and Weight Solids of Surface Coatings

Problem: Very inaccurate for multicomponent, high solids coatings

Importance of problem:

Relative importance: Affects multicomponent-component, high solids coatings.
Magnitude of errors: Large
Cost of current method: Moderate
Importance assigned by districts: Moderate
Other considerations: None

Overall importance: Moderate

Resolution effort:

Development of direct method to measure VOC would eliminate some of the problems. However, since sampling techniques are a very important issue to consider when developing a method for multicomponent coatings further development in sampling techniques will be needed.

Estimated cost of resolution effort: $50,000 (if development of special sampling techniques is necessary)

Test Method: ASTM D 2697: Volume Nonvolatile Matter in Clear or Pigmented Coatings

Problem:

Determination of volume nonvolatile matter by liquid displacement is difficult and inaccurate.

Importance of problem:

Relative importance: This method is generally not used. Volume percent solids are provided by the manufacturer based on formulation data.
Magnitude of errors: Large
Cost of current method: Low
Importance assigned by districts: Low
Other considerations: None

Overall importance: Low

Resolution effort:

Method using a helium pycnometer is currently under review by ASTM Committee D01.21.

Estimated cost of resolution effort: None

Test Method: ASTM D 4017: Water in Paints and Paint Materials by Karl Fischer Method

Problem:

Latex resins used in some waterborne coatings are not soluble in standard Karl Fischer solvents.

Importance of problem:

Relative importance: Affects some latex resin coatings.
Magnitude of errors: Moderate

Cost of current method: Low
Importance assigned by districts: Low
Other considerations: None

Overall importance: Low

Resolution effort:

Revised method extracting the water into methanol has been developed and is being tested by ASTM Committee D01.21. Use of a homogeneizer for dispensing the coating in methanol is viewed as helpful.

Estimated cost of resolution effort: None

Test Method: EPA Method 25: Determination of Total Gaseous Nonmethane Organic Emissions as Carbon

Problem:

The method can be inaccurate for some processes, doesn't measure actual emissions, and is very expensive to use.

Importance of problem:

Relative importance: Affects all measurements using this method.
Magnitude of errors: Large/Very Large
Cost of current method: High
Importance assigned by districts: Moderate
Other considerations: None

Overall importance: High

Resolution effort:

New methods need to be developed, particularly methods which can accurately quantify polar organic compounds, including oxygenated compounds.

Estimated cost of resolution effort: Unknown. Could be very large.

Test Method: EPA Method 25A: Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer

Problem:

The method lacks reproducibility (relative to a blind), can't be used with combustion sources, doesn't measure oxygenated VOCs, must be corrected for exempt compounds, and is cumbersome and expensive to use.

Importance of problem:

Relative importance: Affects all measurements using this method.
Magnitude of errors: Large/Very Large
Cost of current method: High
Importance assigned by districts: Moderate
Other considerations: None

Overall importance: High

Resolution effort:

New methods need to be developed, particularly methods which can accurately quantify polar organic compounds, including oxygenated compounds.

Estimated cost of resolution effort: Unknown, Could be very large

Test Method: EPA Capture Efficiency Protocols

Problem:

Protocols require use of permanent or temporary total enclosure. This requirement is extremely expensive, inconvenient, and potentially dangerous. It also makes spot inspections impossible. South Coast District Protocol addresses theses concerns, and EPA is adding alternative protocols.

Importance of problem:

Relative importance: Affects all measurements using this method.
Magnitude of errors: Large/Very Large
Cost of current method: Very high
Importance assigned by districts: High
Other considerations: Method is rarely used because of problems.

Overall importance: High

Resolution effort:

New methods need to be developed involving the collection of integrated samples using evacuated containers, cryogenic sampling, the use of tracers.

Estimated cost of resolution effort: $100,000

Transfer Efficiency Test Methods: ASTM D 5066, ASTM D 5009, ASTM D 5286, ASTM D 5327

Problem:

No transfer efficiency test methods are currently approved by the EPA or other federal regulatory agencies. They are generally only useful for the relative ranking of spray equipment, not for the absolute determination of transfer efficiency.

Importance of problem:

Relative importance: Affects all measurements using these methods
Magnitude of errors: Large/Very Large
Cost of current method: Not applicable
Importance assigned by districts: Low
Other considerations: None

Overall importance: Low

Resolution effort:

Transfer efficiency test methods are currently being studied by SCAQMD.

Estimated cost of resolution effort: Unknown

VI

Procedure for Updating Test Method Priority Ranking

The following procedure is recommended for ARB personnel or other researchers seeking to update the priority ranking for VOC test methods for coatings and coating operations identified in this report, as well as to identify any new test method problems. It builds on the methodology developed in this study, and assumes that a data base containing all existing California APCD and AQMD regulations dealing with VOC emissions from coatings and coating operations has been created. Procedures for creating such a data base are given in Chapter II of this report. However, we recommend that the existing data base be used. The software file is included with this report.

For convenience the update procedure has be broken down into the following steps.

(I). A data base (see, for example, Table 1) containing all existing California APCD and AQMD regulations dealing with VOC emissions from coatings and coating operations must be updated, along with all current test methods described in those regulations. A survey letter and questionnaire should be sent to all the districts listed in Table A1, once the appropriate contact person has been identified. A list of contact names, including addresses, and telephone numbers of the persons contacted at all 34 districts in California during this study are provided in Table A1, and may be used as a starting point. Telephone calls should be made prior to sending the survey letter in

order to confirm the name and address of the appropriate contact person at all 34 districts.

The form of survey letter and questionaire may be drafted from the example provided (Survey letter A1). We recommend making several modifications in the survey letter to be sent to the districts. The name and address of each person to whom the survey is sent should be printed on the survey response form, and a space should be provided for the signature of the person responding. The question regarding laboratories which perform the test methods should be dropped, since it did not receive any positive responses. The responses from the districts to the survey letters will provide the basis for updating the database.

(II). After the district regulations and test methods have been documented and processed according to the methodology described in Chapter 2, the data should be analysed to identify any new problems with the current test methods. A survey letter and questionnaire should be sent to the people identified by our previous surveys (listed in Table 6), as well as any new individuals or laboratories identified from contacts with the districts, ARB, EPA, ASTM, or by database or Internet searches. A suggested format for this survey letter and questionaire is provided (Survey A2). However, the questionaire should be updated to reflect the priority list of test method problems developed in this study, along with any new test method problems identified in the survey of district representatives (Step 1).

Although we strongly recommend that the survey letter and questionnaire focuss on specific problems which have been previously identified, any new problems which may have been recognized subsequent to this study should not ignored. Thus it is essential that the survey letter and questionnaire clearly and unequivocally request information on any problems with VOC test methods for coatings and coating operations, not just the ones identified in this study.

(III). A library and database search should be undertaken to identify all studies conducted to develop or improve test methods related to VOC emissions from coating operations since the previous review. A methodology for conducting a thorough computer library and database search using the facilities of the University of California, Davis Library is described below. A list of search terms (title words, key word formats) are given in Table A5. We also recommend that similar searches be conducted through the Internet, including the World-Wide-Web (WWW), using the web browsers such as Netscape, Internet Explorer or Mosaic. Internet "search engines" such as AltaVista, Lycos, Infoseek, and Yahoo are particularly useful. A list of Internet addresses containing information relating to regulations and test methods concerning VOC emissions from coatings and coating operations is given in Table A6. The ability to use the Internet to conduct online searches is is expanding rapidly, and it is likely that much more information will be

available in the future. However, this list should provide a starting point for future Internet searches.

Traditional library and database searches can be conducted using the facilities at the University of California, Davis library, including the Melvyl Library system (which provides access to the entire resources of all the University of California libraries), the library CD-ROM network, and the government documents collections. In addition, the use of on-line database services, including the Internet and the on-line Chemical Abstracts Service are recommended. The Air Resources Board library is another resource. In the present study the database search included, but was not limited to the databases and systems listed in Table A4.

The databases should be searched using the "title-word" format. If no citations are found using this format, then an alternate key-word format should be implemented. In most instances, we found that "title-word" was the most effective method for obtaining article citations, using the prescribed search strategy format. The search strategy format should incorporate specific search terms into an algorithm, thus enabling a more systematic means of literary surveying to be conducted. Table A5 identifies useful search terms for implementing a search strategy.

Searches conducted through the Internet are facilitated when web browsers such as Netscape,Internet Explorer, or Mosaic are used, in conjunction with "search-engines". The purpose of searching through the Internet is to locate information relating to VOC's, coatings, coating

operations and methods of testing for VOC's in coatings and coating operations, that might not be readily found in standard databases. The search strategy should incorporate initial search terms (e.g. environment, EPA, government regulations) followed by terms (e.g. coatings, coating operations, VOC , methods of testing for VOC's) more specific in content to the subject matter being sought. We found that this search strategy enabled us to systematically narrow the specific search field to obtain useful information.

(IV) After the responses to the surveys have been received, and the data base search has been conducted, a third survey letter should be sent out to **selected** federal, state, and local district representatives identified in the previous surveys. This survey letter would include a list of **all** the test method problems identified by the previous two surveys. The respondents of this survey would be asked to evaluate the impact each test method has on districts according to a qualitative formula. The evaluation scores will provide the basis for ranking test method problems in Step V. A sample survey form is included in the Appendix (Survey A3)

The formula we propose for evaluating the impact of test methods identified in Survey 3 is described below. The formula consist of 4 factors, to which a total of 100 points (maximum) would be assigned. (100 points -> highest impact)

1. *The relative importance of the test method (40 points)*

This factor includes the relative magnitude of the source being tested, the nature of the materials being tested (i.e. are they toxic, extremely reactive, etc.), and the availability of alternative test methods. The allocation of points may be subdivided among the following categories, but the total should not not exceed 40.

(i) Magnitude of emissions affected by test: 0-40 points

(ii) Toxicity of emissions affected by test: 0-20 points

(iii) Availability of alternative test methods: 0-10 points

If detailed emissions data for coatings are not available, then the relative impact of a test method can be estimated by the percentage of district rules which cite the test method in question (i.e. if the district has 10 rules relating to coatings, and 6 of them cite a particular test method, then it can be estimated that the test method affects >50% of coatings emissions for that district). For the purpose of this project, the magnitude of the emissions affected by the test method is likely the most important category, since water base coatings are not likely to be toxic.

2. *The magnitude of the errors associated with the test method (30 points)*

This factor includes the relative standard deviation (RSD) of the test method as determined by interlaboratory studies, and the absolute accuracy of the test method, which may be more difficult to determine. In assessing the impact this factor has on implementing the test method, respondents may choose to assign points according to the following criteria:

(1) RSD>50%: 30 points

(2) RSD 20-50%: 15-29 points

(3) RSD 10-20%: 5-15points

(4) RSD<10%: <5 points

If the survey respondents do not have information regarding the magnitude of errors associated with the test method, they do not have to respond to this category.

3. *The cost of implementing the current test method (20 points)*

This factor includes not only the cost of the testing laboratory or other organization performing the test method, but also the cost to the organization (factory, auto-body shop, etc.) whose emissions are being tested. For example, if the performance of the test method requires shutting down or disrupting the productive activities of a facility thereby placing excessive demands on personnel, then the cost can be far greater than the simple cost of performing the test method. Possible dangers to workers or testing personnel associated with performing certain test methods can also be included in this factor. A maximum total of 20 points would be allotted to this factor, the higher the number of points, the more costly it is to implement the method.

4. *The importance assigned by the districts and other regulatory agencies to the test method (10 points)*

This factor may differ from the relative importance of the test method assigned in section (1) due to considerations specific to particular regions, including public perceptions, differing patterns of industrial development,

political considerations, etc. A maximum total of 10 points would be allotted to this factor.

The exact weight given to each factor described above is somewhat arbitrary, but we believe it generally reflects the relative importance of the different factors. Factor (4) is given a relatively low importance because the views of the districts and other regulatory agencies will be considered in the other three factors as well.

On the survey form, it would also be helpful if respondents identify which of the following categories each test method belongs:

(i) >50% of coatings emissions affected by test method:

(ii) 20-50% of coatings emissions affected by test method:

(iii) <20% of coatings emissions affected by test method:

Examples of using this formula on test method problems identified in this study are given in Section VII.

(V). Finally, after the responses to the survey letters and questionnaires have been analyzed, and the database and Internet searches, and other information gathering have been completed, the collective input from the districts should be sought to obtain an informed evaluation of the importance of the test method problems and to arrive at a priority ranking of them.There are several approaches that we can recommend: (a) a face-to-face meeting; (b) video/teleconference meeting; (c) internet meeting using group-ware software such as Lotus Notes, Microsoft Exchange. What ever format is used to conduct such a meeting, it should allow for the interaction and free

exchange of information among representatives of the various government regulatory agencies (EPA, ARB, SCAQMD, etc.), and other groups such as ASTM, testing laboratories, universities, and industry. If the expenses can be justified, we recommend a face-to-face meeting be held. The other formats depend heavily on the availability of necessary technology at the various sites, and the software expertise of the participants. A conventional teleconference meeting becomes unmanageable and inefficient when the number of participants exceeds six. One possibility to minimize the costs of a face-to-face meeting, is to arrange it to coincide with another meeting or conference which many of the participants would already be planning to attend, such as the annual meeting of the Air & Waste Management Association, or the semi-annual meetings of the ASTM Committee D01.21.

Before the meeting is held, a position paper should be prepared by the personnel conducting the updating of the test method priority ranking. The position paper should list all the test method problems identified in steps (I)-(III) and the impact these methods have on districts (Step IV). A meeting should then be organized by ARB, in conjunction with the South Coast and Bay Area AQMDs, and should include representatives of the districts, testing laboratories, the EPA, ASTM Committee D01.21, and the ARB. It is essential that the position paper be distributed to the participants well in advance of the meeting, with an appropriate agenda that includes the overall objectives of the meeting. The duration of meeting will depend on the format. At a minimum, the organizers should allow sufficient time to thoroughly

evaluate all of the test method problems identified, and to arrive at a generally agreed -upon priority ranking of the problems.

If a face-to face meeting is held, then the meeting should be held in a convenient location to enable all participants to attend in person. One possible format for such a meeting is a conference, with talks by invited speakers from organizations such as ASTM and the EPA. The talks could be presented in the morning, and then the afternoon could be devoted to discussion and evaluation of the test method problems. Organizing the meeting as a conference with talks by experts on test methods would make it more interesting and useful to district representatives, and therefore might encourage greater participation on their part.

VII

Sample Application of the Ranking Formula

In ranking the test method problems (List A in Section V) according to the formula which we have proposed, we have chosen to include all of the problems identified for a particular test method in a single ranking of that test method. We have done this because any effort to resolve problems with a particular test method should take all of the problems into account. A solution to a particular test method problem might exacerbate other existing problems, or even create new ones, and these possibilities must be considered when devising any effort to resolve existing test method problems.

The problems with EPA Method 24 are an example of these considerations. The principal problem with Method 24 is the inability of the method to accurately determine the VOC levels of low-VOC, high water-content coatings due to the way in which the VOC content is calculated. However, any effort to resolve this problem should also take into account the other existing problems with Method 24, such as the inclusion of volatile compounds such as ammonia and acetone (which has been exempted from consideration as a VOC), the inaccuracy of the method with regard to multi-component coatings, etc. A test method (such as the one proposed by the Research Triangle Institute) which eliminates the problem of Method 24 due to the "minus-water" calculation, but which still includes all of the exempt volatiles such as ammonia, acetone, and the halogenated hydrocarbons, is not

an effective solution when all of the problems identified for Method 24 are taken into consideration.

It may not be possible to resolve all of the existing problems with a particular test method by a single effort, and the development of a new method may produce new problems, or elevate minor problems to major status. Therefore a continuing process of evaluation is necessary, which takes into account the previously identified problems with a particular test method, as well as any new problems which may have arisen as a result of changes in the test method. The overall goal of the evaluation process is always the improvement of the precision and accuracy of the test methods, the simplification of the methods, and the reduction of the cost of the testing process, in that order.

Priority Ranking of Test Method Problems

We rank the test methods problems using the ranking procedure described in Section VI (Step IV). In order of priority the results are:

Test Method: EPA Method 24 and ASTM D 3960: Determination of Volatile Matter Content, Density, Volume Solids, and Weight Solids of Surface Coatings

1. Relative Importance of Test Method: 40 points
2. Magnitude of the Error Associated with Test Method: 30 points
3. Cost of Test Method: 10 points
4. Importance Assigned by Districts: 10 points

Total Score: 90 points
Ranking: 1

Test Method: EPA Method 25: Determination of Total Gaseous Nonmethane Organic Emissions as Carbon

1. Relative Importance of Test Method: 30 points
2. Magnitude of the Error Associated with Test Method: 30 points
3. Cost of Test Method: 20 points
4. Importance Assigned by Districts: 5 points
Total Score: 85 points
Ranking: 2

Test Method: EPA Method 25A: Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer

1. Relative Importance of Test Method: 30 points
2. Magnitude of the Error Associated with Test Method: 30 points
3. Cost of Test Method: 20 points
4. Importance Assigned by Districts: 5 points
Total Score: 85 points
Ranking: 2

Test Method: EPA Capture Efficiency Protocols

1. Relative Importance of Test Method: 30 points
2. Magnitude of the Error Associated with Test Method: 25 points
3. Cost of Test Method: 20 points
4. Importance Assigned by Districts: 5 points
Total Score: 80 points
Ranking: 4

Transfer Efficiency Test Methods: ASTM D 5066, ASTM D 5009, ASTM D 5286, ASTM D 5327

1. Relative Importance of Test Method: 10 points
2. Magnitude of the Error Associated with Test Method: 20 points
3. Cost of Test Method: 15 points
4. Importance Assigned by Districts: 5 points
Total Score: 50 points
Ranking: 5

Test Method: ASTM D 4017: Water in Paints and Paint Materials by Karl-Fischer Method

1. Relative Importance of Test Method: 20 points
2. Magnitude of the Error Associated with Test Method: 10 points
3. Cost of Test Method: 5 points
4. Importance Assigned by Districts: 5 points
Total Score: 40 points
Ranking: 6

Test Method : ASTM D 2697: Volume Nonvolatile Matter in Clear or Pigmented Coatings

1. Relative Importance of Test Method: 10 points
2. Magnitude of the Error Associated with Test Method: 15 points
3. Cost of Test Method: 5 points
4. Importance Assigned by Districts: 5 points

Total Score: 35 points
Ranking: 7

VIII

Procedure for Identifying Projects to Resolve Test Method Problems

After the test methods problems have been identified and ranked according to the procedures described in Section VI, a procedure for identifying projects to resolve problems needs to be implemented. We recommend that all test method problems which achieved a total score of more than 75 points according to the test method ranking formula be evaluated to identify projects which address potential solutions to the problems.

The procedure for identifying projects to resolve problems with current test methods for VOC analysis of coatings and coating methods should include the following steps:

1. *Identify and Allocate Personnel and Other Resources Necessary to Conduct the Evaluations.*

This includes identifying the people who will perform the work, designating the person who will manage the project, determining how much time can be charged to the project, and setting a time schedule for completing the project. If staff resources needed to conduct various aspects of the project (see below) are not available within ARB, those portions of the evaluation project should be put out for competitive bid.

2. *Survey Current Method Development Activity for VOC Analysis of Coatings*

There are a relatively small number of agencies which are regularly involved in method development for VOC analysis of paints and other coatings. The principal agencies involved are the American Society for Testing and Materials (ASTM), the U.S. Environmental Protection Agency (EPA), the California Air Resources Board (CARB), and the Bay Area and South Coast Air Quality Management Districts (BAAQMD and SCAQMD).

The ASTM is an organization whose purpose is the coordination of ongoing method development and evaluation in all areas of science and technology involving American business and industry. It is made up of a number of committees and subcommittees comprised of representatives of federal, state, and local governments, universities, and businesses and industries affected by the test methods. The particular committee dealing with Paints and Related Coatings is ASTM Committee D01, and the Chemical Analysis of Paints and Paint Materials is the responsibility of Subcommittee D01.21 (K.H. Fujimoto, Chair). Committee D01 meets twice a year for four days, with the next scheduled meetings in San Francisco on June 23-26, 1996; and Fort Lauderdale, Florida on January 26-29, 1997. The subcommittee reports from the meetings are published approximately four months after the meetings (i.e. in November or December, and May or June) in the Journal of Coatings Technology.

The ASTM subcommittees are involved in a continuous process of method development and evaluation, including the organization of 'round-robin' interlaboratory testing of proposed methods before they are approved

by the ASTM subcommittees. Therefore, the appropriate ASTM subcommittee (in the case of paints and other coatings, Subcommittee D01.21) is the best place to start in any survey of current test methods and test method problems.

The U.S. EPA is charged with the responsibility of developing and validating test methods for a wide range of environmental pollutants. They are ultimately responsible for establishing the official test methods which are used for measuring most environmental pollutants, and which are cited in most state and local regulations relating to environmental pollution. Therefore, it is important to consult the relevant section of the EPA in conducting any survey of test methods and test method problems. The EPA is not involved in continuous evaluation of test methods, but they do conduct test method development, and they provide funds to outside agencies to develop and evaluate test methods.

The CARB, BAAQMD, and SCAQMD act in the same manner as the EPA, but on a somewhat smaller scale. They are involved in test method development, and they fund outside agencies to develop and evaluate test methods. Therefore, relevant sections within these agencies need to be consulted in conducting surveys of test methods and test method development.

A list of key personnel involved in test method development should be produced in the course of the survey of current test method development (above). It should include key members of the relevant ASTM committees,

and scientists involved in test method evaluation and development at the EPA, CARB, BAAQMD, and SCAQMD.

3. *Define the Scope of the Problem with Current Methods*

For example, if a test method has more than one problem, it is necessary to identify the parameters which are affected by each problem with the method, and how they affect the overall precision and accuracy of the test method in question. It is important to determine which elements of the test method are actually causing problems, what their precision and accuracy are, and to establish goals for the precision and accuracy of any new or modified test methods.

The goals for the precision and accuracy of new or modified test methods should be determined by consultation with the key personnel in test method development identified in the previous step. The goals must reflect both the precision and accuracy required for the test method to provide useful data for regulatory purposes. Although it is not necessary at this stage to undertake a full cost analysis, it is advisible to consider the cost and difficulty in achieving the goals, so that alternative measurements which are less expensive or difficult are considered, but which still fulfill the purpose of the original test method.

4. *Feasibility Study and Cost Analysis*

It is extremely important to identify any possible elements of the proposed efforts to resolve test method problems which would make it impossible to achieve the goals established in the previous step (for example,

if no technology exists to perform a particular measurement with the required precision and accuracy, or if the cost of performing the measurements is prohibitively expensive). In this step, a cost analysis of new test method development must be undertaken. For each of the measurements on the priority list in, it is necessary to estimate the cost of developing new or modified test methods, based upon existing technology. In addition to estimating the cost of developing new test methods, an estimate should also be made of the cost of implementing any new methods, including the cost of new equipment which might be required by laboratories, and personnel costs such as training or the necessity to hire more highly skilled workers.

It is anticipated that after a cost analysis is undertaken on each of the goals identified in Step 3, it may be necessary to return to Step 3 to seek alternative mesurement techniques because the projected costs are unrealistic. In some circumstances it may not be possible to estimate reliably the cost of developing a new or modified test based on the goals established in Step 3. Howver, any uncertainty uncovered in the feasibility study will be reflected in the next step which establishes a priority list .

5. *Develop Priority List of Measurements Requiring New Test Methods*

This list is related to the priority list of test method problems, but is more specific. A particular test method may contain a number of subsidiary methods required to measure different parameters, all of which go into the overall result which the test method seeks to produce. The test method may

have problems with one or more of the subsidiary measurements, and it is necessary to develop a priority listing of the specific measurements which require new or modified test methods. The cost estimate from Step 4 is included at this time. In particular, it would be desirable to have some measure of impact of the improved test method versus development and implementation costs. Data collected from districts during the updating of test method problems described in Section VI may be useful in establishing this impact factor.

The list should then be distributed to the key personnel in test method development identified previously, and a final list should be prepared based upon their responses.

6. *Determine if ARB can Perform Method Development*

Once the final priority list of measurements requiring new or modified test methods has been prepared, it should be determined if ARB can perform the method development itself, or in collaboration with SCAQMD and BAAQMD. It may be possible for ARB and the AQMDs to perform preliminary measurements to better define the problem with a particular test method, and perhaps reduce the cost of resolving it.

7. *Draft RFP for New Test Method Development*

The RFP for the development of new test methods should be distributed to the list of key personnel identified above, and revised according to their responses.

8. *Issue RFP, Evaluate Proposals, and Award Contracts.*

IX
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X

Appendices

Survey A1: LETTER SENT TO DISTRICTS FOR SURVEY OF RULES

November 18, 1994

<<DATA districts>>

<<name>>
<<title>>
<<street>>
<<city state zip>>

Dear <<full name>>:

We are conducting a survey for the Air Resources Board to evaluate the test methods currently in use and under development to measure emissions of volatile organic compounds (VOCs) from coatings and coating operations (i.e. paints, inks, coatings, adhesives, polyester resins, and cleaning solvents).

We believe that it is important to get information on test methods and method development from the people involved on a day-to-day basis with implementing the regulations regarding VOC emissions from coatings and coating operations. Therefore, we are contacting you and the other officials at local air pollution control districts in California to get information regarding current regulations and the test methods which are necessary to implement those regulations (and proposed regulations and methods currently under consideration).

The results of the survey will be made available to the participating districts, and the recommendations to the Air Resources Board regarding testing problems and test method development will be formulated in collaboration with a panel of local district representatives.

On the accompanying questionnaire we have listed all current regulations which we have identified for your district which deal with VOC emissions from coatings and coating operations. If we have omitted any current regulations, or if you have any regulations currently under consideration, we would appreciate it if you would list them in the space provided on the questionnaire.

We would also like to know if your district performs any of its own testing for VOC emissions from coatings and coating operations. If you do not perform your own testing, we would appreciate it if you could provide us with the names of organizations or laboratories which do perform these tests, and which you have found to provide acceptable results.

Finally, we would appreciate any comments which you or your staff would like to make regarding the current test methods, including their appropriateness, precision and accuracy, reliability, and cost effectiveness.

You can respond by mailing us the questionnaire in the enclosed envelope, or you can fax us your response at (916)-752-7872. If you have any questions regarding the questionnaire, please call David Pierotti at (916)-752-1823 or (916)-759-2037.

We would appreciate receiving your response within two weeks. Your responses are of great interest to us, and we are looking forward to incorporating them into our report to the Air Resources Board.

Sincerely,

David Pierotti
Research Professor

Brian Higgins
Professor and Chair

TEST METHODS SURVEY FOR LOCAL AIR POLLUTION CONTROL DISTRICTS

Current regulations regarding VOC emissions from coatings and coating operations

Additional regulations regarding VOC emissions from coatings and coating operations (including proposed regulations under consideration)

Agencies or laboratories found acceptable by district to perform test methods

Comments on current test methods for VOC emissions from coatings and coating operations (use additional pages if necessary)

Please return to: Department of Chemical Engineering and Materials Science
University of California, Davis
Davis, CA 95616
Fax: (916) 752-7872

Survey A2: LETTER SENT TO TESTING LABS FOR SURVEY OF TEST METHODS

April 1, 1995

<<DATA districts>>

<<name>>
<<title>>
<<street>>
<<city state zip>>

Dear <<full name>>:

We are conducting a survey for the Air Resources Board to evaluate the test methods currently in use and under development to measure emissions of volatile organic compounds (VOCs) from coatings and coating operations (i.e. paints, inks, coatings, adhesives, polyester resins, and cleaning solvents).

We believe that it is important to get information on test methods and method development from the people involved on a day-to-day basis with conducting the test methods and performing the actual analyses in the laboratory. The results of the study will be made available to the participating laboratories, and the recommendations to the California Air Resources Board regarding testing problems and test method development will be strongly influenced by the information we get from laboratories such as yours.

On the accompanying questionnaire we have listed most of the existing test methods for measuring VOC emissions from coating and coating operations. If there are any other methods which we have failed to identify, or which you believe should be included among the existing methods, we would appreciate it if you would list them in the space provided on the questionnaire.

Finally, we would appreciate any comments which you or your staff would like to make regarding the document test methods, including any problems you have had with them, and any suggestions you might have for improving them. Feel free to comment on any aspects of the test methods, including their appropriateness, precision and accuracy, reliability, and cost effectiveness.

You are welcome to make comments and suggestions regarding the test methods at any level, from suggestions for relatively minor, incremental changes in the existing methods up to recommendations for the development of entirely new test methods. We are not committed to any particular approach at the present time, and we are interested in any ideas and suggestions which you might have.

You can respond by mailing us the questionnaire in the enclosed envelope, or you can fax us your response at (916)-752-7872. Please include your name and phone number on the response form. I you have any questions regarding the questionnaire, please call David Pierotti at (916)-752-1823 or (916)-759-2037.

We would appreciate receiving you response within two weeks. Your responses are of great interest to us, and we are looking forward to incorporating them into our report to the Air Resources Board.

Sincerely,

David Pierotti
Research Professor

Brian Higgins
Professor and Chair

SURVEY A2 FOR LABORATORIES PERFORMING VOC TEST METHODS *Continued*

<<DATA laboratories>> <<name>. <<organization>>
Current test methods for VOC emissions from coatings and coating operations

EPA Methods: 18, 24, 24A, 25, 25A, 25B, 25D

ARB Methods: 100, 422, 432

ASTM Methods: D-1613-81 (or 85), D-1639-83, D-3792-79 (or 86), D-1078-86, D-2879-83 (or 86), D-3960-87, D-2369-87, D-4457-85, E-260-85 (or 91)

SCAQMD Methods: 16, 17, 19, 22, 24, 25.1, 26, 302, 303, 304, 305, 309, 310, 311, 312, 316A

BAAQMD Methods: III-9, III-21, III-22, III-23, III-26, III-31, III-35, III-36, IV-ST-7

40 CR 52.741, 40 CFR 60.713, 55 FR 26865

Additional test methods for VOC emissions from coatings and coating operations (including proposed methods under consideration).

Comments on current test methods for VOC emissions from coating and coating operations (use additional pages if necessary).

Name, address, and phone number of person filling out form:

Please return to:

Department of Chemical Engineering and Materials Science
University of California, Davis
Davis, CA 95616
FAX: (916) 752-7872

Survey A3: LETTER TO BE SENT TO SELECTED DISTRICT REPRESENTATIVES FOR EVALUATING IMPACT OF TEST METHOD PROBLEMS

<<DATE>>

<<name>>
<<title>>
<<street>>
<<city state zip>>

Dear <<full name>>:

We are updating our procedures for evaluating problems associated with test methods currently in use and under development to measure emissions of volatile organic compounds (VOCs) from coatings and coating operations (i.e. paints, inks, coatings, adhesives, polyester resins, and cleaning solvents).

From two previous surveys we have identified the following test methods to have significant problems that should be addressed.

<<List of test methods and problems. A possible format is provided in Sec. IV, List A>>

We are now in the process of ranking these problems and would like you to evaluate the impact each test method listed above has on your district according to the following criteria:

(i) Relative importance of test method (40 points)
- (a) Magnitude of emissions affected by test
- (b)Toxicity of emissions affected by test
- (c) Availability of alternative test methods

(ii) Magnitude of errors associated with test method (30 points)

(iii) The cost of implementing the current test method (20 points)

(iv) The importance assigned by the districts and other regulatory agencies (10 points)

We have enclosed guidelines << taken from Sec. VI>> for assigning points to the various categories.

We would appreciate receiving your response within two weeks so that your input is available to the committee members who will be ranking the test methods on <<date>>. Your response is of great interest to us and we look forward to hearing from you.

Sincerely,

TableA1:SURVEYRESPONSEOFDISTRICTCONTACTS

District	Contacts	Phone No.	Address	Survey Response
Amador County APCD	Roxanne Keith	(209) 223-6406	208 Court Street Jackson, CA 95642	Yes
Bay Area AQMD	Gary Fend Rudy Zerrudo	(415) 749-4604 (415) 771-6000	939 Ellis Street San Francisco, CA 94109	Yes
Butte County APCD	Gina Facca	(916) 891-2882	9287 Midway, Suite 1A Durham, CA 95938	Yes
Calaveras County APCD	Jearl D. Howard	(209) 754-6521	Government Center, 891 Mountain Ranch Rd. San Andrews, CA 95249	
Colusa County APCD	Harry Krug	(916) 458-5891	100 Sunrise Blvd., Suite F Colusa, CA 95932	
El Dorado County APCD	Ronald Duncan Dennis Otani	(916) 621-5300 (916) 621-6662	2850 Fair Lane Court, Bldg. C Placerville, CA 95667	Yes
Feather River AQMD	Ken Corbin	(916) 634-7659	463 Palora Avenue Yuba City, CA 95991	
Glenn County APCD	Ed Romano	(916) 934-6500	P. O. Box 351, 720 North Colusa Street Willows, CA 95988	
Great Basin Unified APCD	Dr. Ellen Hardebeck Duano Ono	(619) 872-8211 (619) 872-8211	157 Short Street, Suite 6 Bishop, CA 93514	Yes
Imperial County APCD	Stephen Birdsal Gaspar	(619) 339-4606 (619) 339-4314	150 S. 9th Street El Centro, CA 92243	
Kern County APCD	Joel Heinricks Tom Paxson	(805) 861-3502 (805) 861-2593	2700 M Street Suite 290 Bakersfield, CA 93301	
Lake County AQMD	Ross L. Kauper	(707) 263-7000 (707) 263-3225	883 Lakeport Blvd. Lakeport, CA 95453	Yes
Lassen County APCD	Kenneth R. Smith	(916) 257-8311 extension 110	175 Russel Avenue Susanville, CA 96130	
Mariposa County APCD	Dr. Charles Mosher	(209) 966-0200	P.O. Box 5, 4988 11th St. Mariposa, CA 95338	
Mendocino County APCD	David Faulkner	(707) 463-4354	Courthouse, 306 E. Gobbi Ukiah, CA 95482	Yes
Modoc County APCD	Leslie Wright	(916) 233-6419	202 West 4th Street Alturas, CA 96101	Yes

Table A1 *Continued*: SURVEY RESPONSE OF DISTRICT CONTACTS

District	Contacts	Phone No.	Address	Survey Response
Mojave Desert AQMD	Charles L. Fryxell	(619) 245-1661	15428 Civic Drive, Suite 200 Victorville, CA 92392	
Monterey Bay AQMD	Fred Thoits	(408) 647-9411	24580 Silver Cloud Court Monterey, CA 93940	Yes
North Coast Unified AQMD	Wayne Morgan Bob Clark	(707) 443-3093 (707) 443-3093	2389 Myrtle Avenue Eureka, CA 95501	Yes
Northern Sonoma County APCD	Michael W. Tolmasoff	(707) 433-5911	109 North Street Healdsburg, CA 95448	Yes
Northern Sierra AQMD	Noel A. Bonderson	(916) 274-9360	P. O. Box 2509 Grass Valley, CA 95945	Yes
Placer County APCD	Walter Arenstein	(916) 889-7130	DeWitt Center, 11464 B Ave. Auburn, CA 95603	
Sacramento Metropolitan AQMD	Kerin Leonard Pat Tedeschi	(916) 386-6182 (916) 386-6644	8411 Jackson Road Sacramento, CA 95826	Yes
San Diego APCD	Clint Cooney Natalie Zlotin	(619) 694-3301 (619) 694-3307	9150 Chesapeake Drive San Diego, CA 92123	Yes
San Joaquin Valley Unified APCD	Joe Nazareno Rajinder Atwal	(209) 497-1000 (209) 497-1075	1999 Tuolumne Street, Suite 200 Fresno, CA 93721	Yes
San Luis Obispo County APCD	Robert W. Carr	(805) 781-5912	2156 Sierra Way, Suite B San Luis Obispo, CA 93401	Yes
Santa Barbara County APCD	Doug Allard	(805) 961-8800	26 Castilian Drive, B-23 Goleta, CA 93117	Yes
Shasta County AQMD	R. Michael Kussow, P.	(916) 225-5674	1826 Butte Street Redding, CA 96001	Yes
Siskiyou County APCD	James R. Massey, Jr.	(916) 842-8029	525 South Foothill Drive Yreka, CA 96097	
South Coast AQMD	Corie Choa Glenn Kasai	(909) 396-2172	21865 E. Copley Drive Diamond Bar, CA 91765	Yes
Tehama County APCD	Heidi W. Hill Gray Bovee	(916) 527-3717 (916) 527-3717	P.O. Box 38, 1750 Walnut Street Red Bluff, CA 96080	Yes

Table A1 *Continued*: SURVEY RESPONSE OF DISTRICT CONTACTS

District	Contacts	Phone No.	Address	Survey Response
Tuolumne County APCD	Gerald A. Benincasa, Mike Waugh	(209) 533-5693 (209) 533-5693	2 South Green Street Sonora, CA 95370	Yes
Ventura County APCD	Keith Duval	(805) 645-1410	669 County Square Drive Ventura,Ca 93003	Yes
Yolo-Solano County AQMD	Ken Selover	(916) 757-3650 (800) 287-3650	1947 Galileo Court, Suite 103 Davis, CA 95616	Yes

Table A2: BASIC DATABASE LAYOUT (SAMPLE)

District	Bay Area Air Quality Management District
Address	939 Ellis Street San Francisco, CA 94109
Contact 1	Gary Fend
Phone #	(415) 749-4604
Contact 2	Rudy Zerrudo
Phone #	(415) 772-6000
Fax #	(415) 928-8560
Category Number	6
Abbr. Coating Type	Aerospace
Exact Rule Title	Aerospace assembly and component coating operations
Rule Number	29
Test Method 1	BAAQMD III 21, 22
Test Method 2	BAAQMD IV ST-7
Test Method 3	
Test Method 4	
Test Method 5	
Test Method 6	
Status	existing
Last Amended Date	6/1/94
Survey Sending Date	11/18/94
Responded Date	

Table A3: DATABASE OF PERSONNEL INVOLVED IN VOC TEST METHODS FOR COATINGS

Contact 1	Facility	Phone No.	Address
Rudy Zerrudo	BAAQMD	(415) 749-4629	939 Ellis Street San Francisco, CA 94109
Corie Choa	SCAQMD	(909) 396-2172	21865 E. Copley Drive Diamond Bar, CA 91765
Ed Jeung	E. H. S. Air and Industrial Hygiene Labs	(510) 540-2814	2151 Berkeley Way Berkeley, CA 94704
Pete Kosel	ARB	(916) 263-2051	PO Box 2815 Sacramento, CA 95812
D. Patrick Fairley	Calcoast Analytical Labs	(510) 652-2979	4072 Watts Street Emeryville, CA 94608
Robert D. Athey, Jr.	Athey Technologies	(510) 526-3541	P.O. Drawer 7 El Cerrito, CA 94530-0007
Rita Baggs, Dr.	American Research and Testing, Inc.	N/A	4934 S. Figueroa Street Gardenn, CA 90248
Jacob Nercessian	Certified Testing Laboratories, Inc.	(310) 424-9992	2648 East 28th Street Signal Hill, CA 90806
Handall Julio E	Corp Product Finishes Lab	(415) 857-3705	1501 Page Mill RD/MS 6LA Palo Alto, CA 94304
Hiroshi Fujimoto	Advanced Technologies of Michigan	(810) 788-9707	Livonia, MI 48150

Table A3 Continued: DATABASE OF PERSONNEL INVOLVED IN VOC TEST METHODS FOR COATINGS

Contact 1	Facility	Phone No.	Address
Sites Mary E. MS	W R Grace & CO, Dewey & Almy Chemical Division	(617) 861-6600	55 Hayden Ave Lexington, MA 02173
Dr. Joe Benga	PPG Industries	(412) 492-5511	4325 Rosanna DR P.O. Box 9 Allison Park, PA 15101
Dr. William C. Golton	DU Pont-Merck Pharma	(610) 543-0395	509 Beatty RD Springfield, PA 19064
R. K. M. Jayanty	Research Triangle Institute	(919) 541-7026	P.O. Box 12194 Research Triangle Park, NC 27709
Gary McAlister	E. P. A.	(919) 541-1062	Research Triangle Park, NC 27709
Dean Berger	Berger Associates, Inc.	(717) 656-6296	Box 56 Leola, PA 17540-0056
Glenn Jackson, Senior	Special Services Group Bowser Morner	N/A	4518 Taylorsville Road Dayton, OH 45401
Jerry H. Willner	DL Laboratories	(212) 777-4410	116 East 16th Street New York, NY 10003
Ron J. Wingender,	Dexter Corporation	N/A	1 East Water Street Waukegan, IL 60085

Table A3 Continued: DATABASE OF PERSONNEL INVOLVED IN VOC TEST METHODS FOR COATINGS

Contact 1	Facility	Phone No.	Address
Dr. Shari Thannidar	Chemir/Polytech Labs	(800) 659-7659	2672 Metro Building St. Louis, MO 63043
Doug Ezell	TSL Inc. Labs	(417) 864-8924	1512 North Lexington Springfield, MO 65802
Gary Cox	1T1 Anti-Corrosion, Inc.	(713) 771-0688	10175 Harwin, NO. 110 Houston, TX 77036
Carol Morrison	Galbraith Laboratories, Inc.	(615) 546-1335	2323 Sycamore Drive Knoxville, TX 37921
William J. Simonsick,	E. I. DU Pont DE Nemours Corporation, Automotive Products, Marshall R & D Labs	N/A	P.O. Box 3886 Philadelphia, PA 19146
David P. Sheih	Dow Chemical Co.	N/A	Freeport, TX 77541
Theodore Provder	The Glidden Co. Research Center	N/A	16651 Sprague Road Strongsville, OH 44136
A. Monroe Snider, Jr.	PPG Industries, Inc.	N/A	Pittsburgh, PA 15238
Francis X. Young,	Sherwin-Williams Co.	N/A	Cleveland, OH 44113
Carl J. Abraham, Dr.	Inter-City testing & Consulting Corp	(516) 747-8400	167 Willis Ave Mineola, NY 11501

Table A3 Continued: DATABASE OF PERSONNEL INVOLVED IN VOC TEST METHODS FOR COATINGS

Contact 1	Facility	Phone No.	Address
Robert J. Boylan	Air Filter Testing Lab, Inc.	(502) 222-5720	4632 Old Lagrange RD Crestwood, KY 40014
David H. Kuniega	Penndot Materials & Testing Materials & Testing Lab	(717) 787-3966	P. O. Box 2926 Harrisburg, PA 17105-2926
Larry R. Larson	Monarch Analytical Lab, Inc.	(419) 897-9000	349 Tomahawk Drive Maumee, OH 43537-1696
Mary E. McKnight, Dr.	NIST National Energy Laboratory	(301) 975-6714	Bldg 226, RM B348 Gaithersburg MD 20899
Michael McLaurin	Buckman Labs Inc.	(901) 278-0330	1256 N. McLean Blvd Memphis, TN 38108
Judy T. Cheng	Ameron PCS	(714) 529-1951	201 N. Berry Street Brea, CA 92622-1-2-
Thomas D. Talcott	Talcott Development Inc.	(714) 582-3143	17 Pacific Crest Laguna Niguel, CA 92677
Max T. Wills	California Polytechnic State Univ.	(805) 756-2746	Chemistry Department San Luis Obispo, CA 93407
Rudy v. Zerrudo	Bay Area AQMD	(415) 749-4629	939 Ellis Street San Francisco, CA 94109
Tracy W. Barlow	Macon Housing Authority	(912) 752-5047	P.O. Box 4928 Macon, GA 31208

Table A3 Continued: DATABASE OF PERSONNEL INVOLVED IN VOC TEST METHODS FOR COATINGS

Contact 1	Facility	Phone No.	Address
Lydia Bazarko	Sherwin-Williams Co. 1200 Guildhall Bldg Chrm Grp 60	(201) 252-2626	101 Prospect Ave. Cleveland, OH 44115
Simon K. Boocock	steel Structures Painting CNCL	(412) 268-3325	4516 Henry St. Suite 301 Pittsburgh, PA 15213-3728
Darlene R. Brezinski	Consolidated Research Inc.	(7008) 577-5330	200 E. Evergreen Mt. Prospect, IL 60056
Raymond D. Brockaus	E I Du Pont De Nemours & Co.	(313) 468-9098	400 Groesbeck HWY Mt. Clemens, MI 48043
Robert L. Bush	Cleveland Technical Center	(216) 566-3533	601 Canal Road Cleveland, OH 44113
David L. Cammpbell	Rust-Oleum Corp	(414) 947-6811	8105 Fergusson Dr. P.O. Box 70
John Challinor	Swansea Minerals Inc.	(602) 994-9964	6360 E. Rose Circle Dr. Scottsdale, AZ 85251
Edward T. Clegg	US Army Laboratory Command Materials Technology Lab	(617) 923-5286	Arsenal St. ATTN: SLCMT-MEE-ES Watertown, MA 02172-2719
Glenn P. Cuningham	Sherwin-Williams Co.	(216) 566-3303	101 Prospect Ave. N.W. Cleveland OH 44115

Table A3 Continued: DATABASE OF PERSONNEL INVOLVED IN VOC TEST METHODS FOR COATINGS

Contact 1	Facility	Phone No.	Address
David E. Darr	Union Carbide corp. Bldg 740-5202	(609) 443-2232	P.O. Box 8361 S. Charleston, WV 25303
Deepak R. Doshi	Research Division	(215) 641-7441	727 Norristown Rd. spring House, PA 19477
Ravi P. Doshi	Morton International	(803) 292-5700	P.O. Box 3089 Greenville, SC 29602
David Entrekin	MSE Corp.	(601) 354-5422	931 HWY 80 West-Box 1 Jackson, MS 39204
Terry Foster	DREP	(604)-380-2843	FMO Victoria VOS1BO, BC Canada
Hiroshi Fujimoto	Advanced Tech of Michigan	(313) 953-5034	5171 Rock Run West Bloomfield, MI 48322
John M. Furar	PPG Industries Inc. C & R Research CTR	(412) 492-5515	4325 Rosanna Dr. P.O. Box 9 Allison Park, PA 15101
Harold C. Garber	S C M Chemicals	(410) 354-7800	3901 FT Armistead Rd. Baltimore, MD 21226
Cynthia T. Gerus	Uniform Color Co.	(616) 394-3800	942 Brooks Ave. Holland, MI 49423
Robert L. Gilbert	Multicore Solders Inc.	N/A	1715 Jay Ell Dr. Richardson, TX 75081

Table A3 Continued: DATABASE OF PERSONNEL INVOLVED IN VOC TEST METHODS FOR COATINGS

Contact 1	Facility	Phone No.	Address
Tejveen K. Gell	Courtaulds Aerospace	(510) 526-1525	Cedar & 4th Streets Berkeley, CA 94710
Paul R. Guevin Jr.	P r Guevin Associates	(614) 899-1809	P.O. Box 811 Westerville, OH 43086-0811
Richard Hanlon	West Virginia Dept of HWYS	(304) 348-3043	312 Michigan Ave. Charleston, WV 25305
Charles H. Harrison	Atlasta Specialty Ink Co. Inc.	(314) 677-3800	4600 S. Square Dr. High Ridge, MO 63049
Jeffery S. Hinkle	Huls America Inc.	(908) 981-5185	Turner Place Pob 365 Piscataway, NJ 08855-0365
Michael J. Hourani	Angus Chemical Co	(708) 215-8600	1500 E Lake Cook Rd Buffalo Grove, IL 60089
Andrew Hunt	S U N Y Health Science Center Pathology Dept	(315) 464-7146	750 East Adams Street Syracuse, NY 13210
Gary Janezic	Sherwin-Williams Co	(216) 566-2827	601 Canal Rd. Cleveland, OH 44113
Jack G. Lamberton	Reichhold Chemicals Inc.	(919) 990-8039	P.O. Box 13582 Research Triangle, NC 27709
John H. Lauterbach Dr.	Brown & Williamson Tobacco CRP	(912) 755-3436	P.O. Box 1056 Macon, GA 31298

Table A3 Continued: DATABASE OF PERSONNEL INVOLVED IN VOC TEST METHODS FOR COATINGS

Contact 1	Facility	Phone No.	Address
David O. Lawson	PPG Industries Inc. Coatings & Resins	(412) 492-5404	P.O. Box 9-Rosanna Dr. Allison Park, PA 15101
Fred Lewis	E I Dupont De Nemours & Co Inc.	(313) 468-4254	400 Groesbeck HWY MT Clemens, MI 48043
Dirick F. Leys	A G P Surface Control Sys Inc.	(518) 734-5880	Thunderbird Terr POB 388 Windham, NY 12496
Martin J. Mahon	E I DU Pont Nemours & Co	(810) 468-9140	400 Groesbeck HWY MT Clemens, MI 48043
Singh A. Manocha	PPG Industries Pittsburgh Glass R & D	(412) 665-8091	Guys Run Rd P.O. Box 11472 Pittsburgh, PA 15238-0472
William D. Marks	SCM Metal Prods	(919) 544-8090	2601 Weck Dr. Research Triangle, NC 27709
Drawin D. McCunn	Glidden C	(216) 826-5314	16651 Sprague Rd. Strongsville, OH 44136
Soonya W. McDavid	National Paint & Coatings Inc.	N/A	1500 Rhode Island Ave. Washington, DC 20005
Wyatt J. Mills	Du Pont E I De Nemours & Co Marshall Lab	(215) 339-6523	3401 Gray's Ferry Ave. Philadelphia, PA 19146
Lawrence P. Mink	Rohm & Haas Research	(215) 619-5298	727 Norristown Rd. Spring House, PA 19477

Table A3 Continued: DATABASE OF PERSONNEL INVOLVED IN VOC TEST METHODS FOR COATINGS

Contact 1	Facility	Phone No.	Address
John R. Morrison	Union Carbide Corp	(304) 747-5609	P.O. Box 8361 South Charleston, WV 25303
Brude Neff	E I DU Pont De Nemours & Co Marshall Laboratory	(215) 339-6556	3500 Grays Ferry Ave. Philadelphia, PA 19146
Gordon L. Nelson	Florida Inst of Technology	(407) 768-8000	150 W University Blvd. Melbourne, FL 32901-6988
Darwin D. Neveu	Nalin-Neveu Laboratories	(614) 263-3588	P.O. Box 24606 Columbus, OH 43224-0606
Tinh Nguyen	N I S T	(301) 975-6718	Bldg 226-Room B348 Clopper Road Gaithersburg, MD 20899
Daniel J. O'Donnell	Unimin Corp	(203) 966-8880	27 Curtis Rd. Middlebury, CT 06762
Scott W. Orthey	A S T M	(215) 299-5507	1916 Race Street Philadelphia, PA 19103
Richard D. Osterman	Rust-Oleum Corp	(414) 947-6857	8105 Fergusson Dr. Pleasant Prarie, WI 53158
Lynn E. Pattison	B A S F Corp Coatings & Colorants Div	(810) 827-4670	26701 Telegraph Rd. P.O. Box 5009 Southfield, MI 48086-5009

Table A3 Continued: DATABASE OF PERSONNEL INVOLVED IN VOC TEST METHODS FOR COATINGS

Contact 1	Facility	Phone No.	Address
John H. Phillips	Ford Motor Co	(313) 845-1648	15201 Century Dr\Ste 608 Dearborn, MI 48121
Stanislaw Piorek	Metorex Inc.	(215) 741-4482	860 Town Center Dr. Langhorne, PA 19047
Diane E. Potts	Quebecor Printing Quebecor Printing Atglen Inc.	(610) 593-5173	RT 372 Lower Valley Rd. P.O. Box 465 Atglen, PA 19310
Eugene A. Praschan	American Automobile Manufactures Assn	(919) 361-0210	1000 Park Forty Plaza-Ste #300 Durham, NC 27713
Stanley R. Prince	Center for Applied Engrg Inc.	(813) 576-4171	P.O. Box 42010 St. Petersburg, FL 33742
Mark Robillard	Supelco Inc.	(814) 359-3441	Supelco Park Bellefonte, PA 16823
Tracy G. Rogers	ETC Laboratories	(716) 328-7668	AJAX Rd Rochester, NY 14624
Ann M. Ryan	Angus Chemical Co.	(708) 215-8600	1500 E. Lake Cook Rd. Buffalo Grove, IL 60089
Robert M. Schiller	Kerr-Mc Gee Chemical Corp/TSSL	(405) 775-5010	P.O. Box 25861 Oklahoma City, OK 73125
Richard T. Schwartz	Kansas State Dept of Transportation	(913) 296-2231	2300 Vanburen Street Topeka, KS 66611

Table A3 Continued: DATABASE OF PERSONNEL INVOLVED IN VOC TEST METHODS FOR COATINGS

Contact 1	Facility	Phone No.	Address
John R. Sebroski	Miles Inc.	(304) 455-4400	State Route 2 P.O. Box 500 New Martinsville, WV 26155
Michael D. Shesterkin	BASF Corp Southfield R & D Dev Spec	(313) 948-2473	26701 Telegraph Rd POB 5009 Southfield, MI 48086-5009
Mary E. Sites	W R Grace & Co Dewey & Almay Chemical Division	(617) 861-6600	55 Hayden Ave. Lexington, MA 02173
Joanne H. Smith	PPG Industries	(412) 434-3739	One PPG Place 37N Pittsburgh, PA 15272
Monroe A. Snider Jr., Dr.	PPG Industries Inc. Glass Research Center	(412) 665-8725	P.O. Box 11472 Harmaville, PA 15238
Candace Sorrell	US EPA - Source Characterization Group A	(919) 541-1064	MD-19 RES Triangle Park, NC 27711
William C. Spangenberg	Hammond Lead Products Inc.	(412) 344-5811	236 Parker Dr. Pittsburgh, PA 15216
Douglas K. Stephens	Stephens Engineering Labs Inc.	(713) 338-2966	100 E NASA RD 1-Suite 203 Webster, TX 77598
John J. Stourac	Midwest Zinc Corp.	(312) 944-1505	1001 W Weed Street Chicago, IL 60622

Table A3 Continued: DATABASE OF PERSONNEL INVOLVED IN VOC TEST METHODS FOR COATINGS

Contact 1	Facility	Phone No.	Address
Stephen A. Stritar	Crown Cork & Seal	(708) 239-5335	11535 S Central Ave. Alsip, IL 60482
Calvin C. Tatman	S C M Chemicals	(301) 355-3600	3901 Fort Armistead Rd. Baltimore, MD 21226
Kenneth B. Tator	KTA-TATOR Inc.	(412) 788-1300	115 Technology Dr. Pittsburgh, PA 15275
Cliff M. Tebeau	R R Donnelley & Sons Technical Center	(708) 810-5298	750 Warrenville Rd. Lisle, IL 60532-4345
Frank G. Tuozzo	Safety-Kleen Corp.	(312) 694-2700	P.O. Box 92050 Elk Grove Village, IL 60009
Willem Vander Linde	E I DU Pont De Nemours & Co. Marshall R & D Lab	(215) 339-6401	3500 Grays Ferry Ave. Philadelphia, PA 19146
James A. Vysoky	Angus Chemical Co.	(708) 215-8600	1500 E. Lake Cook Rd. Buffalo Grove, IL 60089
John C. Weaver Dr.	Case Western Reserve Univ.	(216) 368-4494	541 Kent Smith Bldg Cleveland, OH 44106
Walter R. West	Shell Development Co.	(713) 544-7726	Westhollow Research Ctr. P.O. Box 1380 Houston, TX 77251-1380
Robert B. Wynne	Hewlett-Packard Co. Little Falls Site	(302) 633-8421	2850 Centerville Rd. Wilmington, DE 19808-1610

Table A3 Continued: DATABASE OF PERSONNEL INVOLVED IN VOC TEST METHODS FOR COATINGS

Contact 1	Facility	Phone No.	Address
Fancis X. Young	Sherwin-Williams	(216) 566-2952	601 Canal Rd. Cleveland, OH 44113
Stephen A. Yuhas Jr.	Solventures Inc.	(908) 636-6420	56 Wick Dr. Fords, NJ 08863

TableA4: DATABASE LISTING

Database	Full Database Listing	Description of Database Holdings
CARL	Colorado Alliance of Research Libraries	Magazines and journals
CAS	Chemical Abstract Service	Chemical abstract database
CAT	Full MELVYL Catalog	UC libraries and California State Library
CC	Current Contents	6500 scholarly journals
CD-ROM	CD-ROM Network at UC Davis	Files on CD-ROM made available through NTIS
CQ	Congressional Quarterly	Legislation/regulations
EUREKA		Research Libraries Group databases and catalog
JRNL	OCLC ArticleFirst	11000 magazines and journals
MAGS	Magazine and Journal	1500 magazines and journals
NASA	Space and Earth Science	NASA On-line Data & Information Service
PE	Periodical Titles	California Academic Libraries List of Serials
TEN	Ten Year MELVYL Catalog	Materials published from 1985-1995
UNCOVER	UnCover	13000 magazines and journals
WCAT	OCLC WorldCat	17000 public academic and other libraries

TableA5: SEARCH TERMS INCORPORATED INTO SEARCH STRATEGY

Search Terms
VOC Coatings
Development of Testing Methods
Volatile Organic Compounds/Materials
...and coatings
...and testing methods
Volatile Organic Coatings
Analysis of Organic Coatings
EPA Regulations

TableA6:INTERNETADDRESSES

Technology Transfer Network:
URL: //ttnbbs.rtpnc.epa.gov

Access to the Technology Transfer Network (an EPA bulletin board) can be achieved by:

1. using the telnet address: telnet: ttnbbs.rtpnc.epa.gov
2. using the Internet (via Netscape or Mosaic)

To access TTN via the Internet, we have found that accessing the Envirosense Home Page with the following URL address will bring you to the page that will provide the appropriate links.
Once at the Envirosense Home Page, continue by clicking on "links to other Systems," followed by "Environmental Protection Agency." You can then access the EPA Bulletin Board by clicking on EPA TTN Bulletin Board System.

Enviroene
URL: http://wastenot.inel.gov/envirosense

Note: When you arrive at the first screen, press "Return" a few times, then just follow directions. Also, for first time users, when it asks for a password, make one up and "remember it." This password will grant you access in the future.

EPA Bulletin Boards

CAAA - Clean Air Act Amendments

EMTIC - Emission Measurement Technical Information Center (emission test methods and testing methods)

AIRS - Air quality and emissions

BLIS - Compilation of air permits from air pollution control agencies

NATICH - Information submitted by EPA, state and local agencies about air toxics programs

COMPLI - Stationary source and asbestos compliance policy

CHIEF - Latest information on air emission inventories and emission factors

ATPI - Current course offering on air pollution

Environmental BBS(Bulletin Board Systems)
URL: http://www.tribnet.com/environ/env_bbs.htm

Solvent Alternatives Guide (Sage)
URL: http://clear.rti.org/husage.htm

CD Roms from NIST (National Institute of Standards and Technoogy)
telnet: ricmenu.nist.gov

VTT Chemical Technology (Finland)
URL: http://www.vtt.fi/ket/kethome.html

IPPS: The Industrial Pollution Projection System
URL: http://www.worldbank.org/html/research/ipps/home.html#toc

Air and Energy Engineering Research Laboratory (AEERL)
URL: http://wastenot.inel.gov/envirosense/program/epaorgs/ord/aeerl.html

Cal/EPA
URL: http://www.cahwnet.gov

CAE Clean Air Engineering
URL: http://www.cleanair.com/users/cae/

Environmental Engineering Informations Sources
URL: http://www.enveng.ufl.edu/process/megacrse/ehs/envlinks.htm

IndustryNet On-line Marketplace
telnet: industry.net
URL: http://www.industry.net/

ATSDR's Hazardous Substance Release/Health Effects Database
URL: http://atsdr1.atsdr.cdc.gov

EnvirolinkNetwork
URL: gopher://envirolink.org

Environmental Guidance Memos
URL: http://venus.hyperk.com

Environmental Law
URL: http://www.law.indiana.edu/law/intenvlaw.html

EPA

URL: http://www.epa.gov

EPA Online Library System
telnet: epaibm.rtpnc.epa.gov

EICBBS (Energy Ideas Clearinghouse)
telnet: //eicbbs.wseowa.gov

The Finishing Technology Hotline
modem: 201/838-0113

STN (patents)
telnet: stn.cas.org (Columbus)

ASTM
URL: http:///www.astm.org/index.html#

ARB
URL: http//www.arb.ca.gov

SCAQMD
URL: http://www.aqmd.gov

Figure A1: Map of Air Pollution Control and Air Quality Management Districts Within the State of California

Figure A2: Identification of Coating Categories (1-5) Regulated in Each Air Pollution Control and Air Quality Management District Within the State of California

Figure A3: Identification of Coating Categories (6-14) Regulated in Each Air Pollution Control and Air Quality Management District Within the State of California

Figure A4: Identification of Coating Categories (15-23) Regulated in Each Air Pollution Control and Air Quality Management District Within the State of California